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(12) **United States Patent**  
**Yu**

(10) **Patent No.:** **US 9,097,832 B2**  
(45) **Date of Patent:** **Aug. 4, 2015**

(54) **LIQUID CRYSTAL DISPLAY (LCD) SYSTEM AND METHOD**

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(73) Assignee: **Xiao Lin Yu**, Fairfax, VA (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1097 days.

(21) Appl. No.: **13/016,976**

(22) Filed: **Jan. 29, 2011**

(65) **Prior Publication Data**

US 2011/0261276 A1 Oct. 27, 2011

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 12/768,638, filed on Apr. 27, 2010.

(51) **Int. Cl.**  
**G02F 1/1333** (2006.01)  
**G02F 1/1335** (2006.01)  
**F21V 8/00** (2006.01)  
**G09G 3/34** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **G02B 6/0081** (2013.01); **G02B 6/0028** (2013.01); **G09G 3/342** (2013.01); **G02B 6/0043** (2013.01); **G02B 6/0075** (2013.01); **G02F 1/133308** (2013.01); **G02F 1/133603** (2013.01); **G02F 1/133608** (2013.01); **G09G 2300/0456** (2013.01)

(58) **Field of Classification Search**

CPC combination set(s) only.  
See application file for complete search history.

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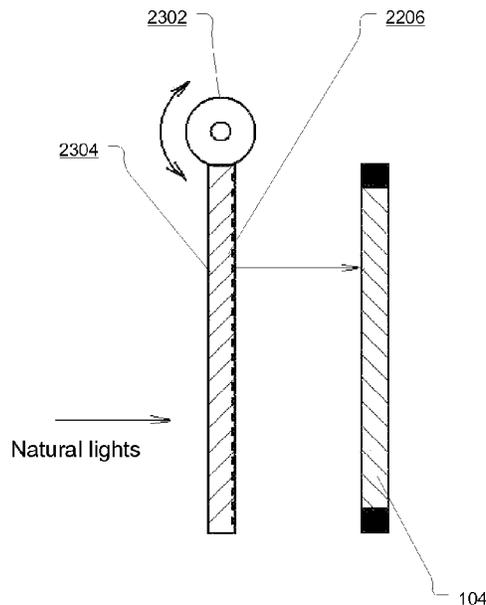
*Primary Examiner* — Wen-Ying P Chen

(74) *Attorney, Agent, or Firm* — Anova Law Group, PLLC

(57) **ABSTRACT**

A liquid crystal display (LCD) system is provided. The LCD system includes a light source and a self-contained display unit including at least a LCD panel and a light guide plate coupled together, wherein the light guide plate is configured to guide light from the light source to the LCD panel as backlight and to structurally support the LCD panel. Further, a plurality of pre-made hollow spaces are contained in the display unit configured to host components of the LCD system. The LCD system also includes a controller contained in the plurality of pre-made hollow spaces and coupled to the LCD panel to control the LCD panel such that the light passing through the light guide plate is used as backlight for operation of the LCD panel.

**18 Claims, 36 Drawing Sheets**



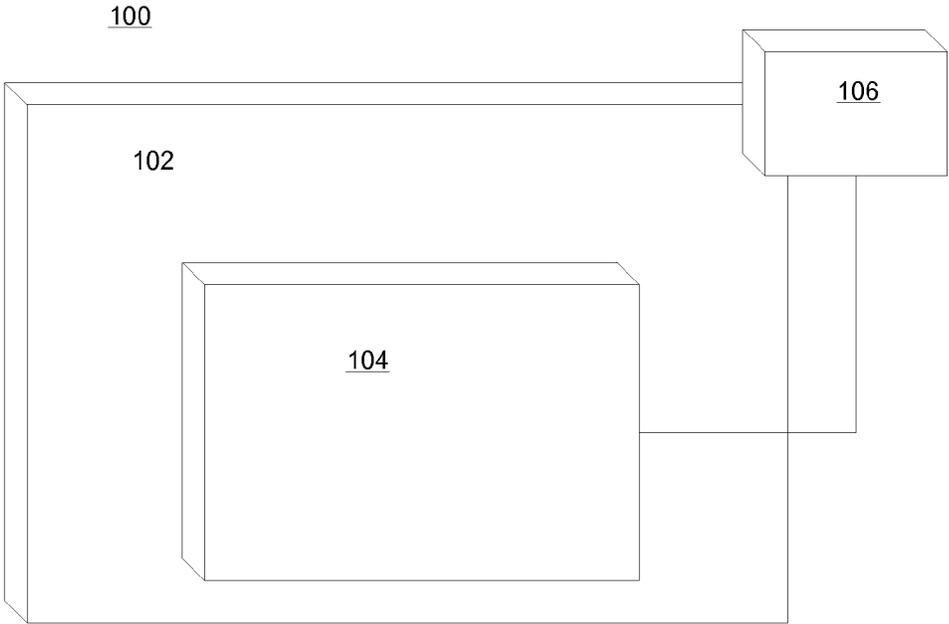


FIG. 1

106

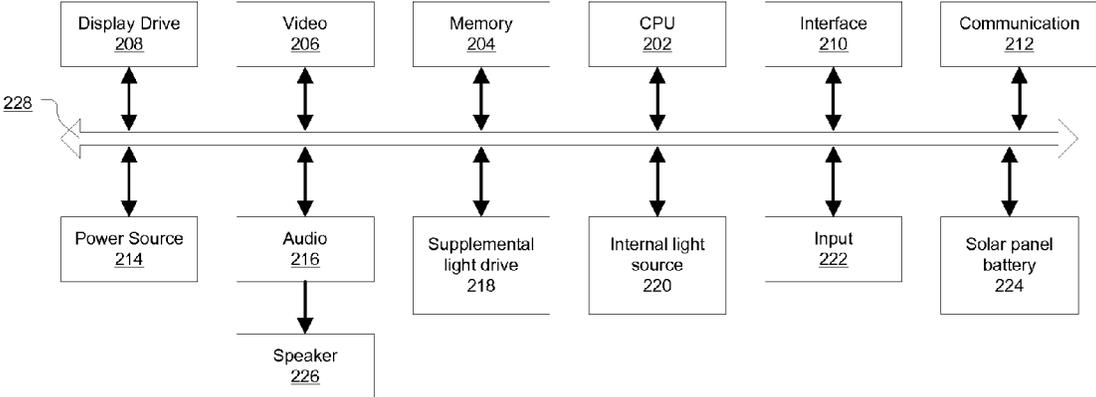


FIG. 2

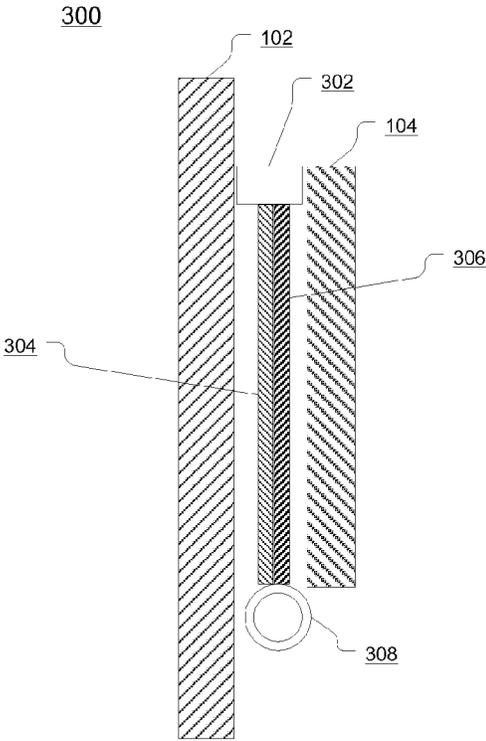


FIG. 3A

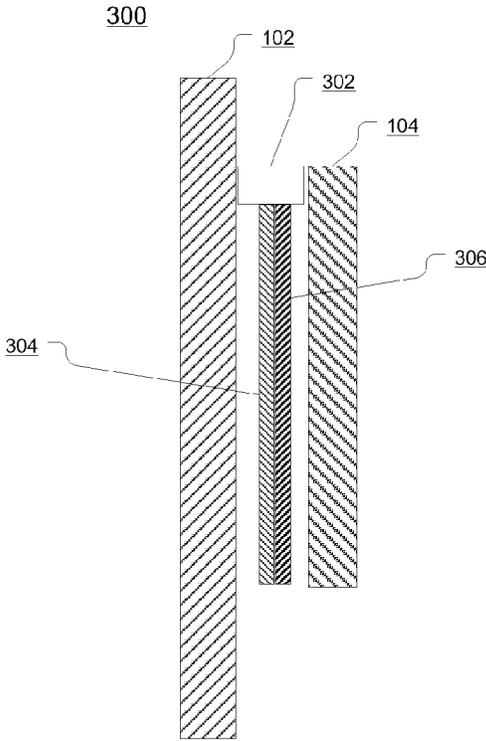


FIG. 3B

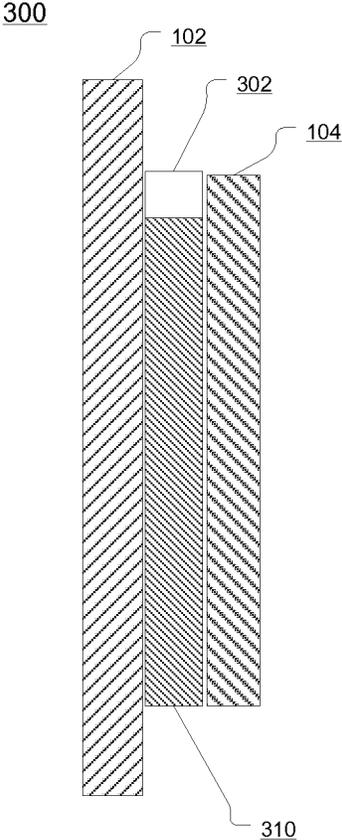


FIG. 3C

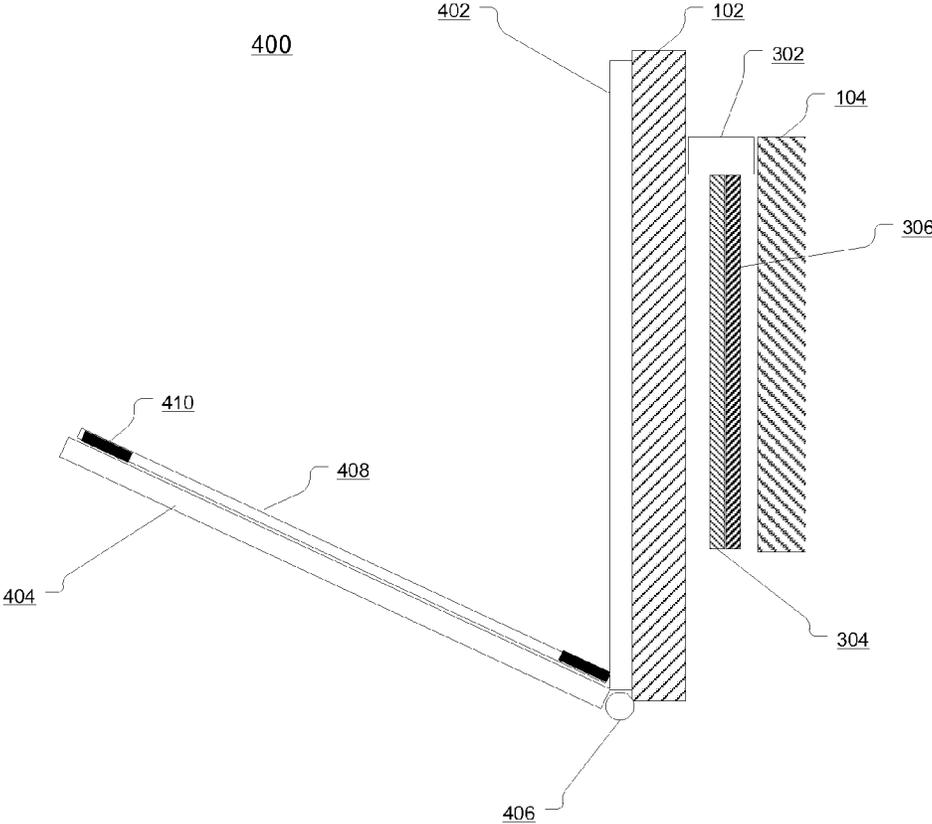


FIG. 4A

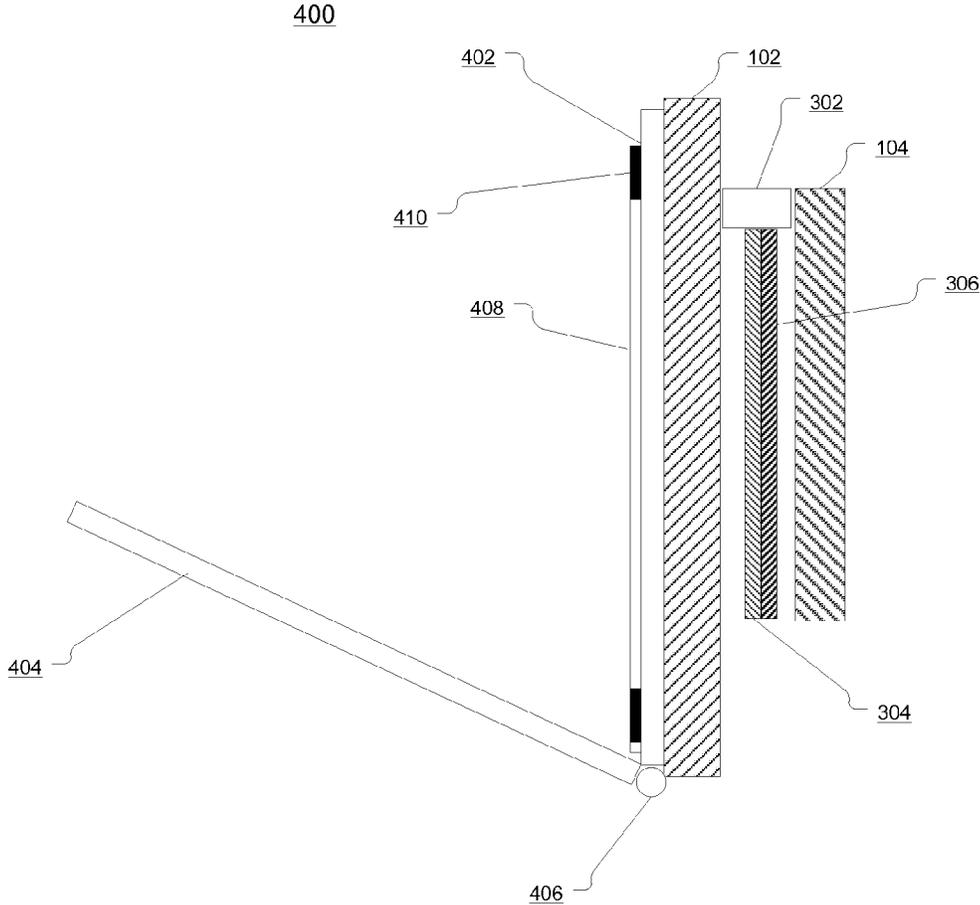


FIG. 4B

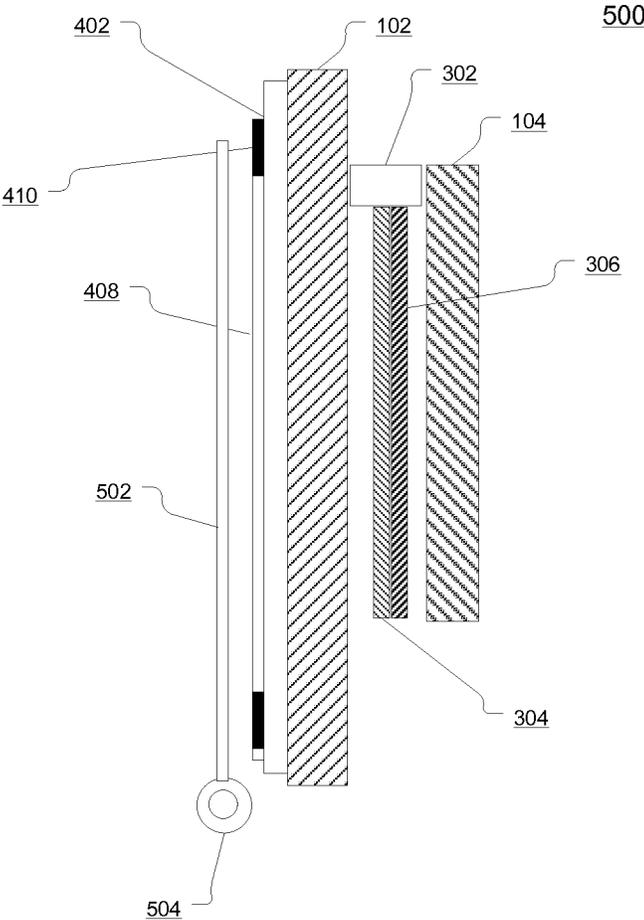


FIG. 5

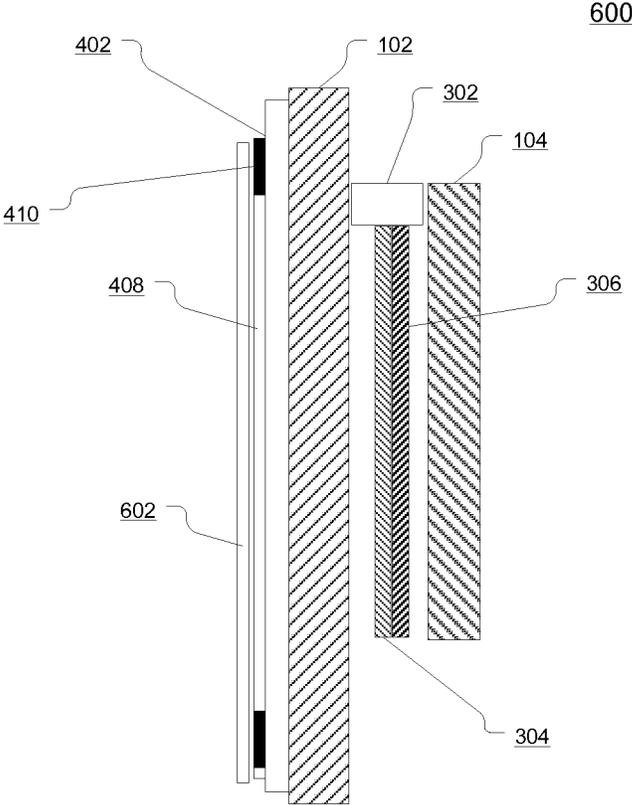


FIG. 6

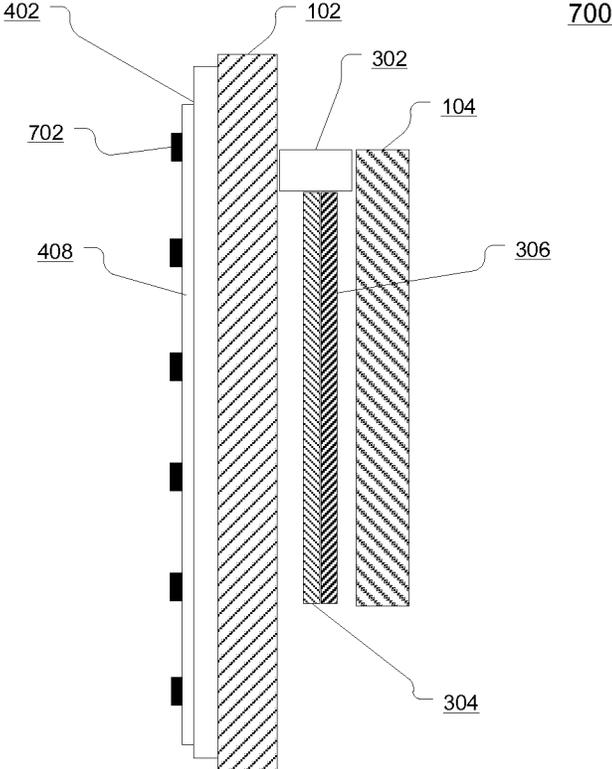


FIG. 7A

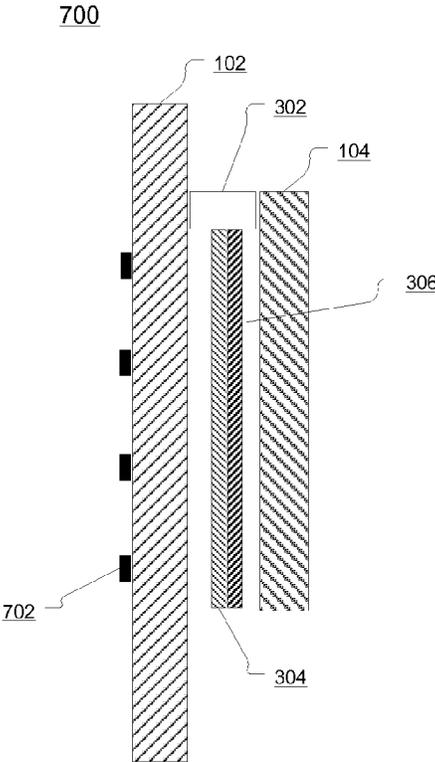


FIG. 7B

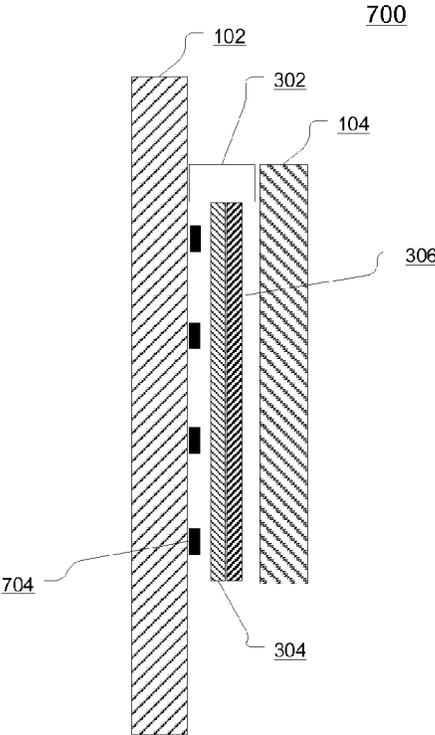


FIG. 7C

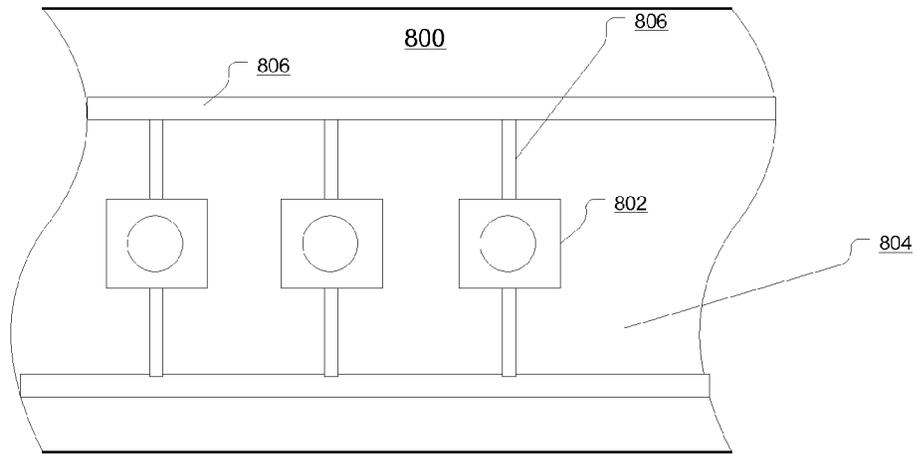


FIG. 8

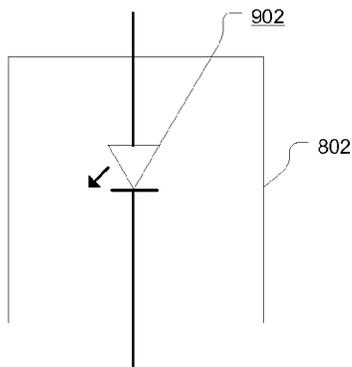


FIG. 9A

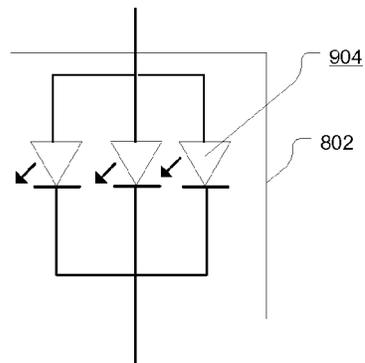


FIG. 9B

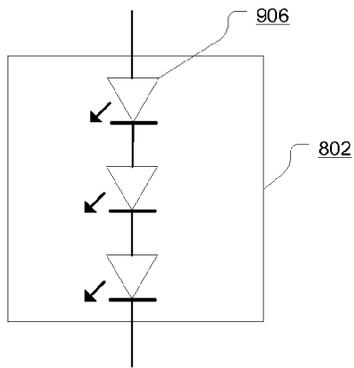


FIG. 9C

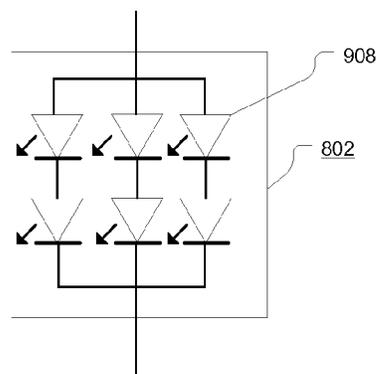


FIG. 9D

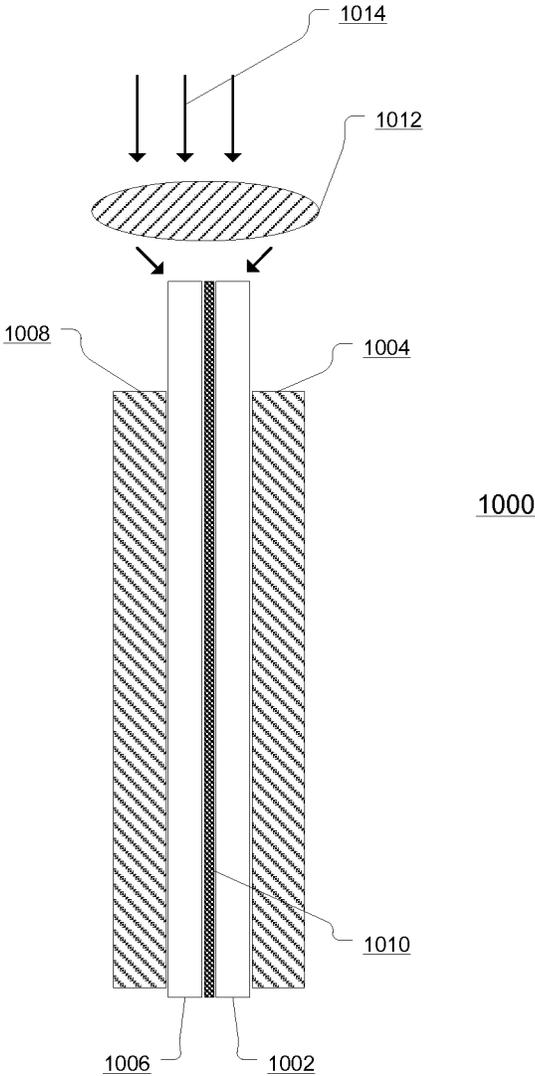


FIG. 10

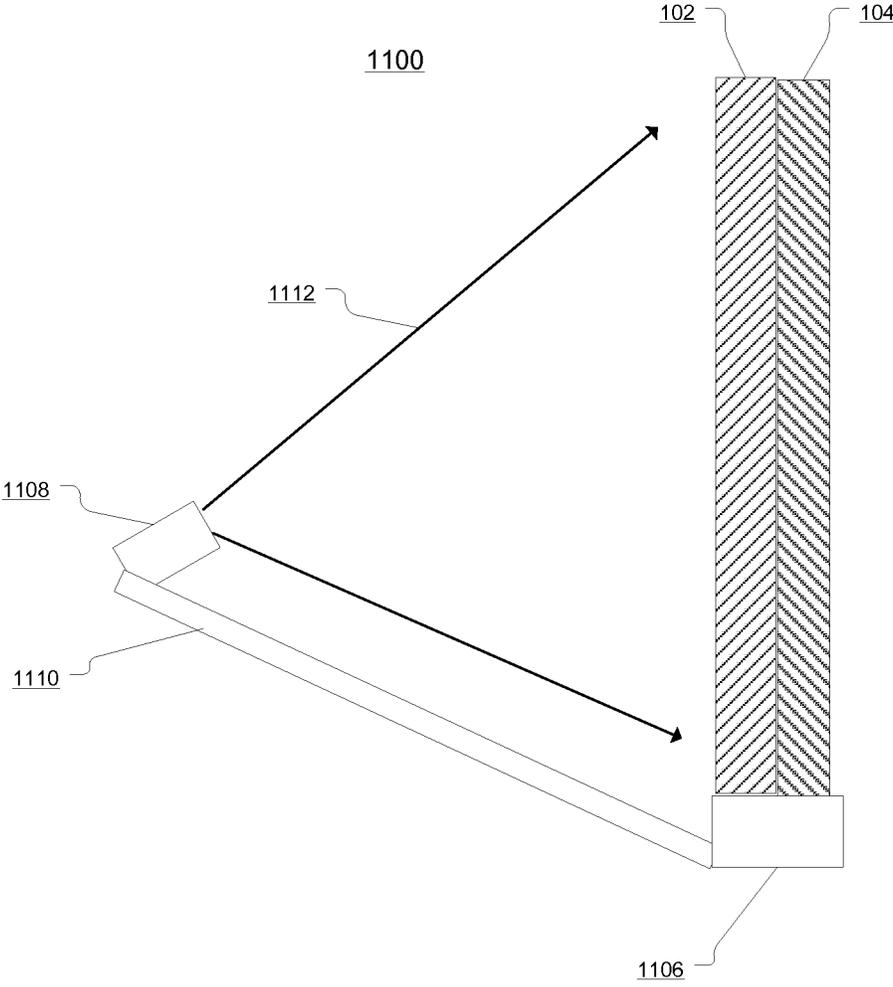


FIG. 11

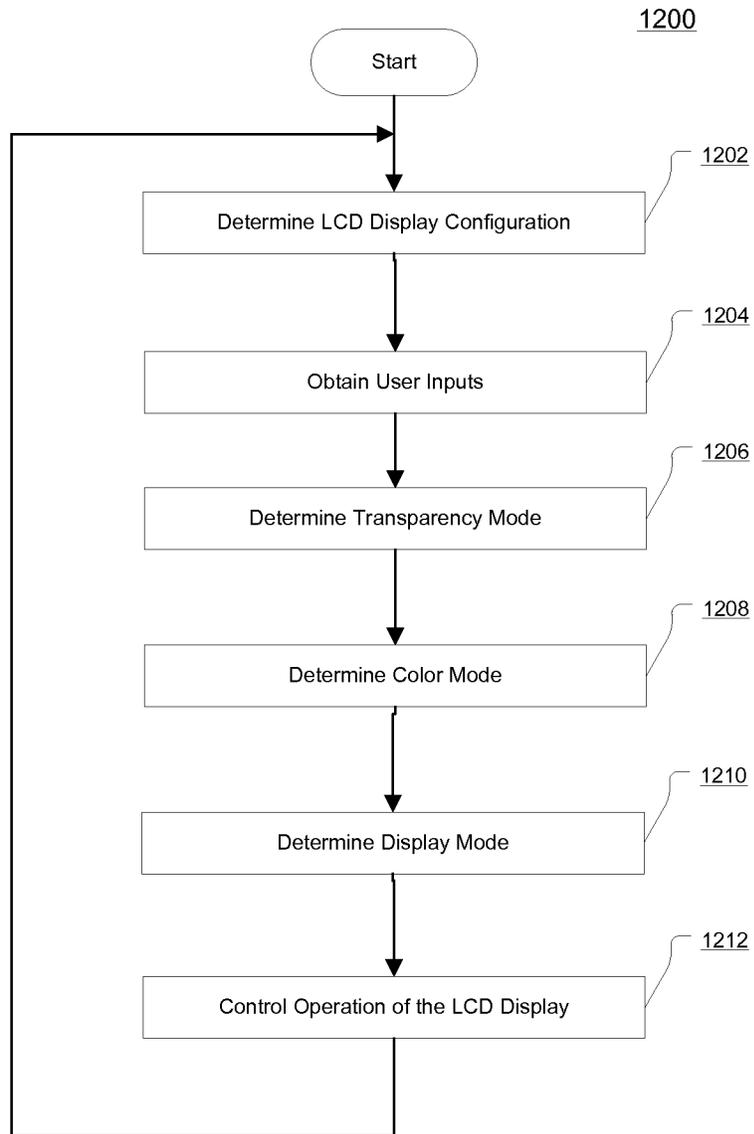


FIG. 12

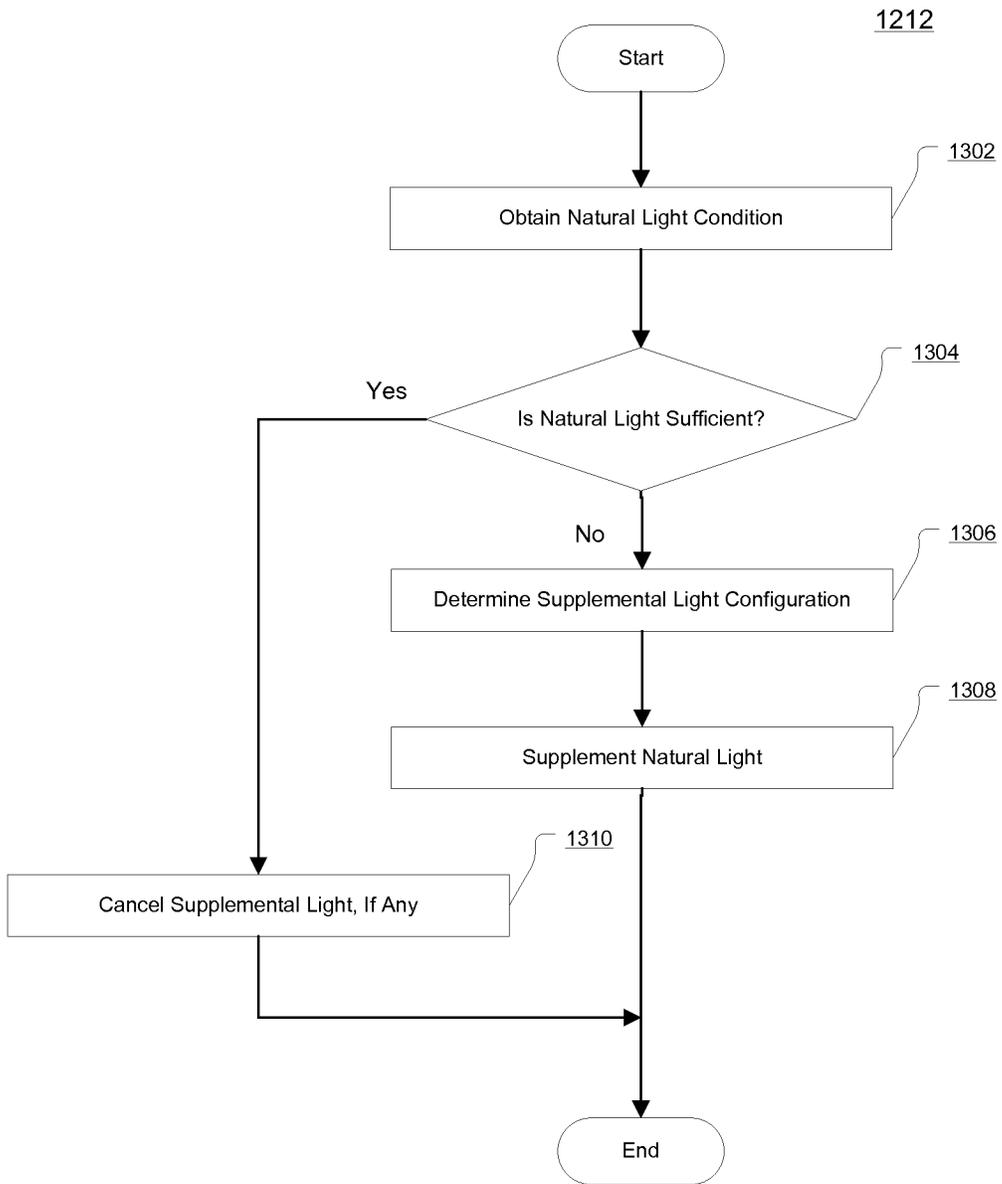


FIG. 13

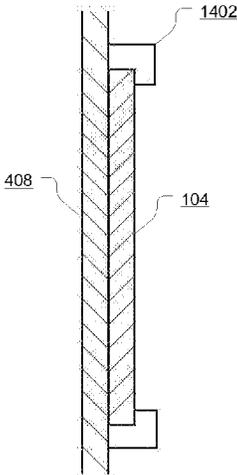


FIG. 14A

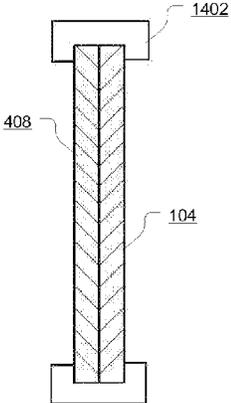


FIG. 14B

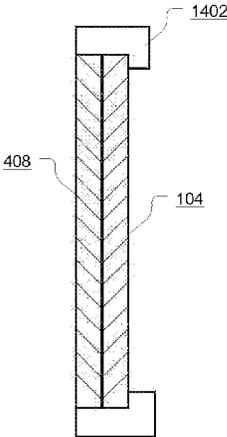


FIG. 14C

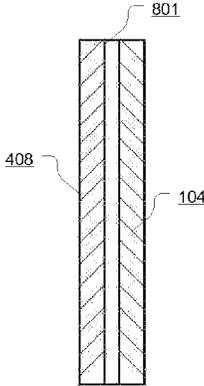


FIG. 14D

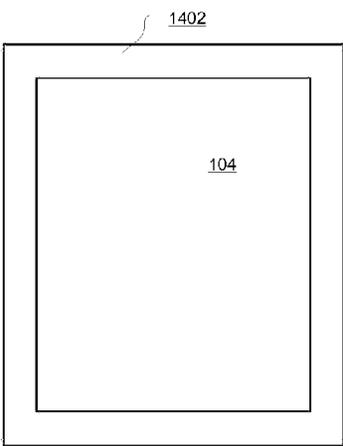


FIG. 15A

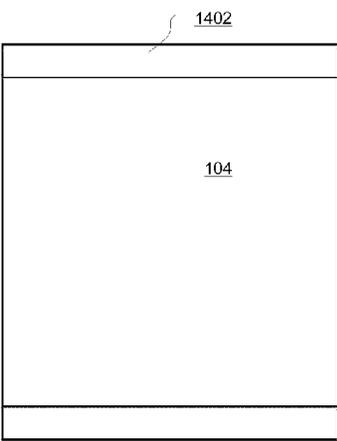


FIG. 15B

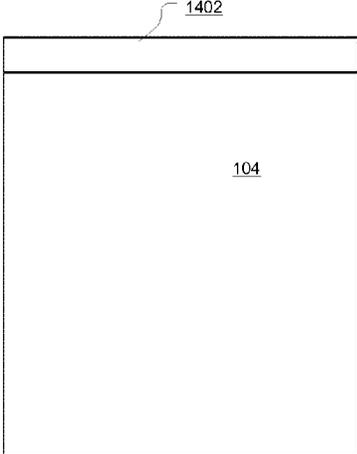


FIG. 15C

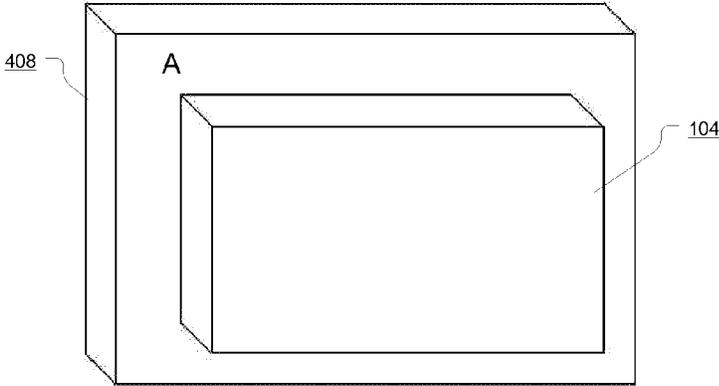


FIG. 16A

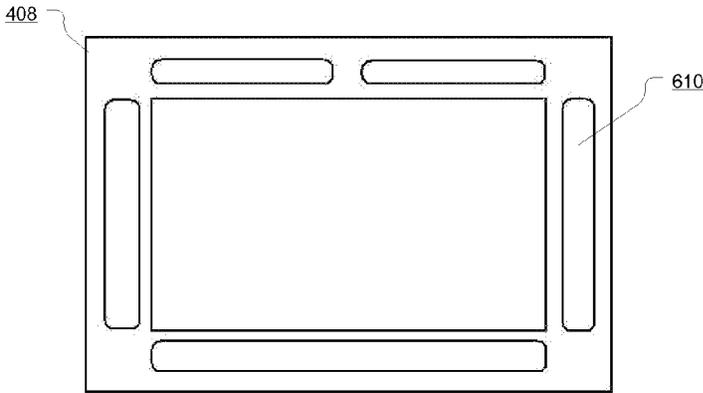


FIG. 16B

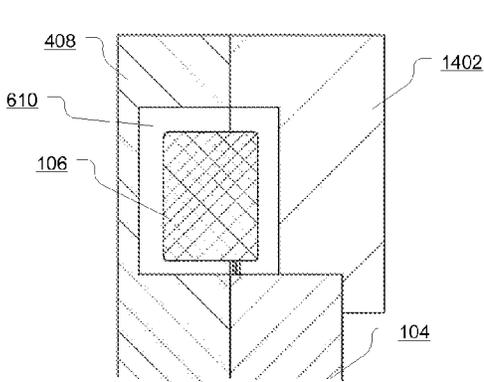


FIG. 16C

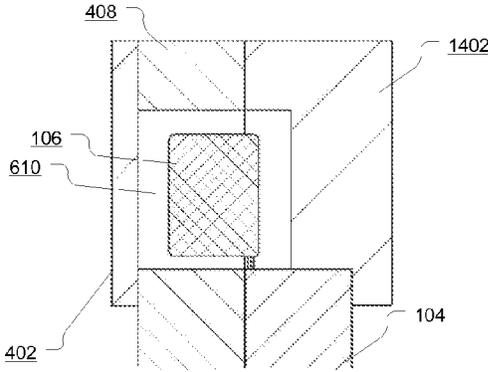


FIG. 16D

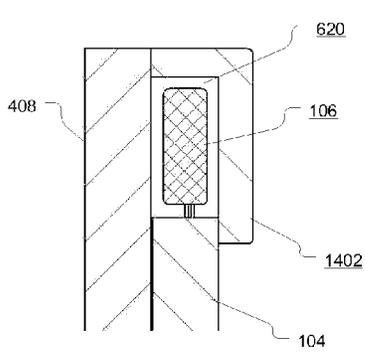


FIG. 17A

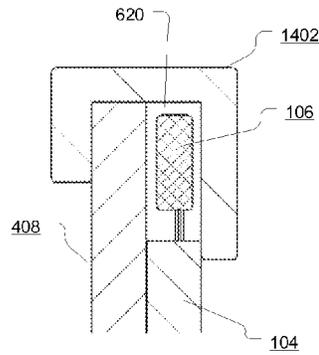


FIG. 17B

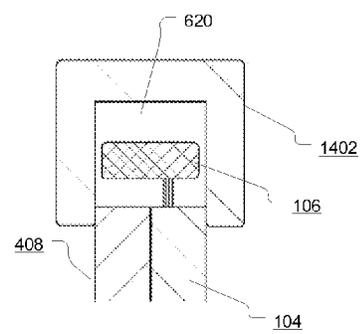


FIG. 17C

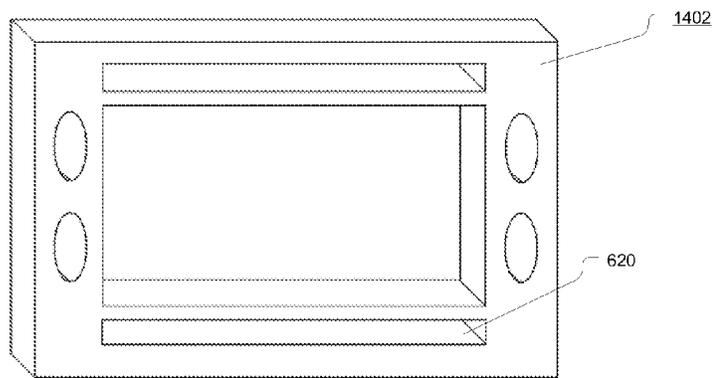


FIG. 17D

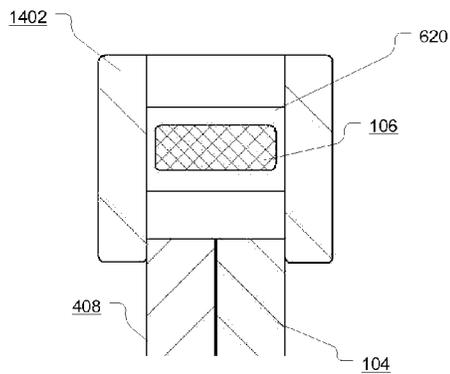


FIG. 17E

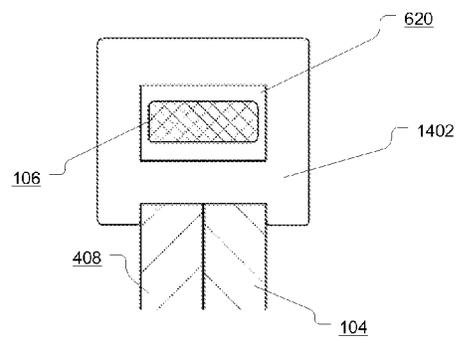


FIG. 17F

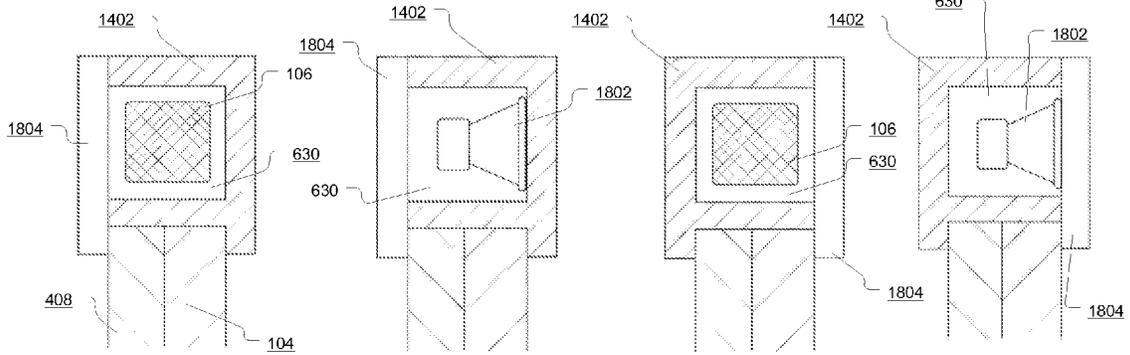


FIG. 18A

FIG. 18B

FIG. 18C

FIG. 18D

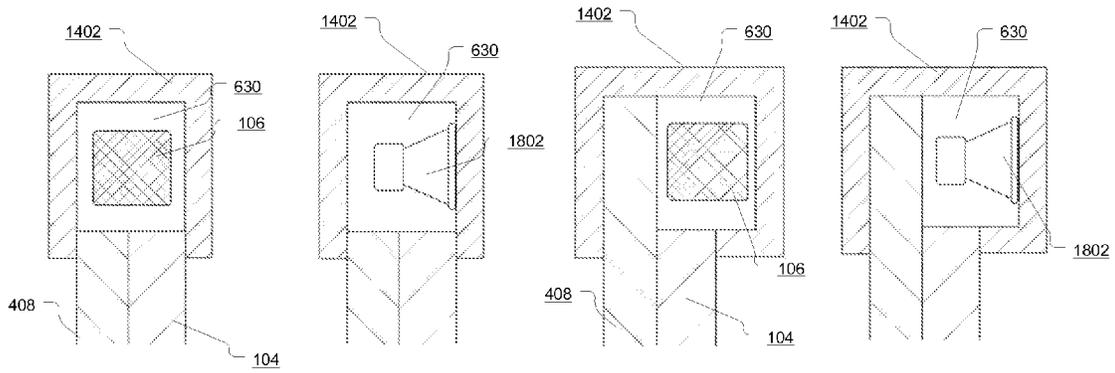


FIG. 18E

FIG. 18F

FIG. 18G

FIG. 18H

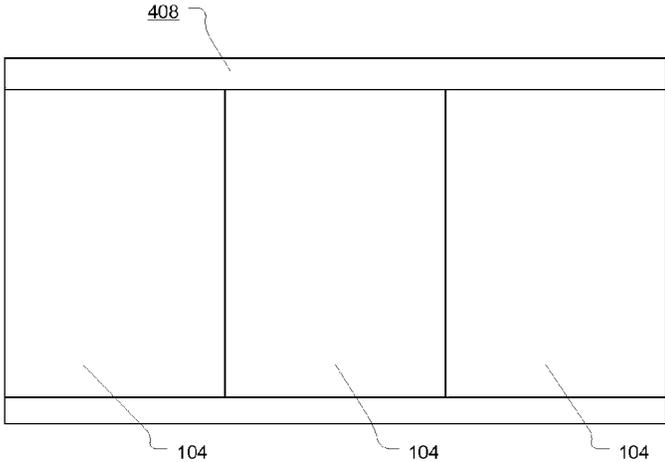


FIG. 19A

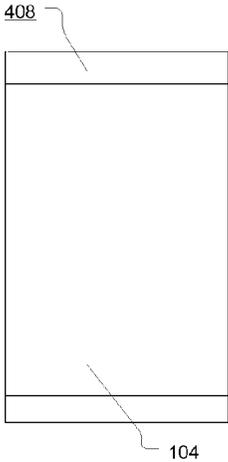


FIG. 19B

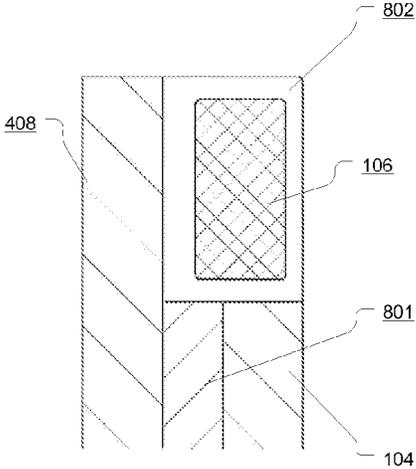


FIG. 20A

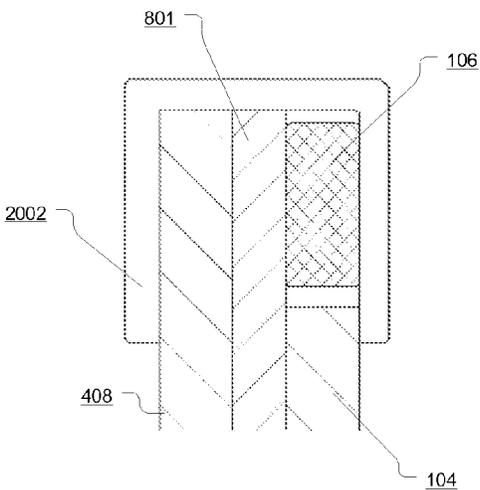


FIG. 20B

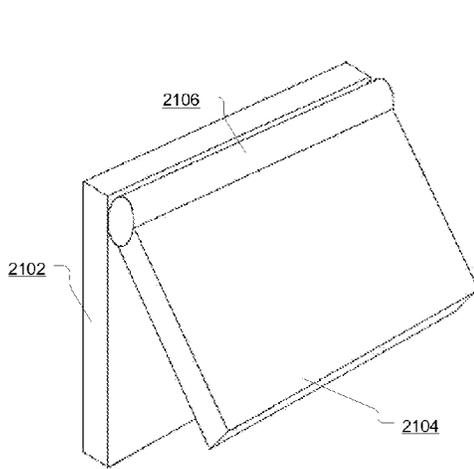


FIG. 21A

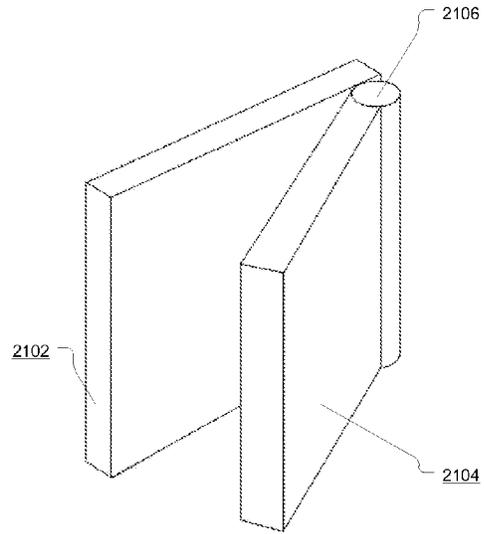


FIG. 21B

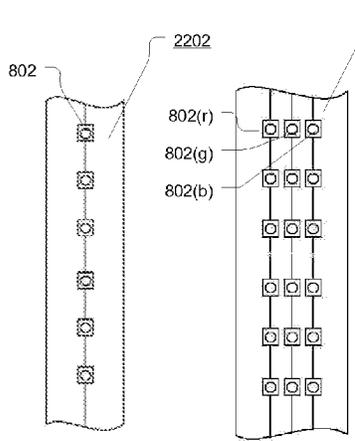


FIG. 22A

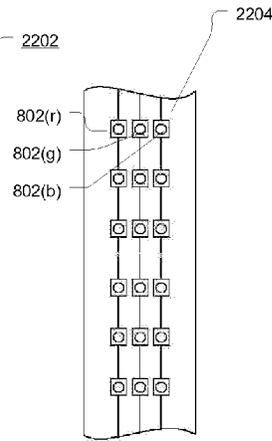


FIG. 22B

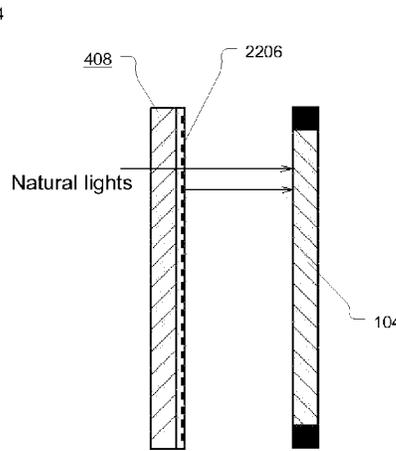


FIG. 22C

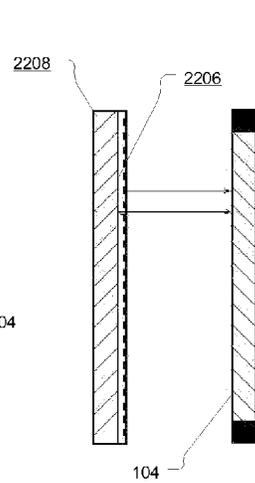


FIG. 22D

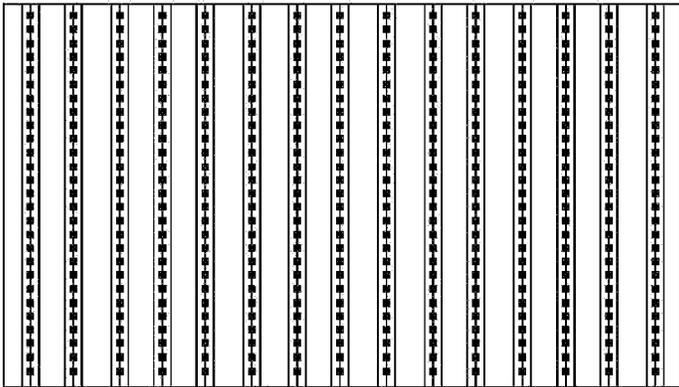


FIG. 23A

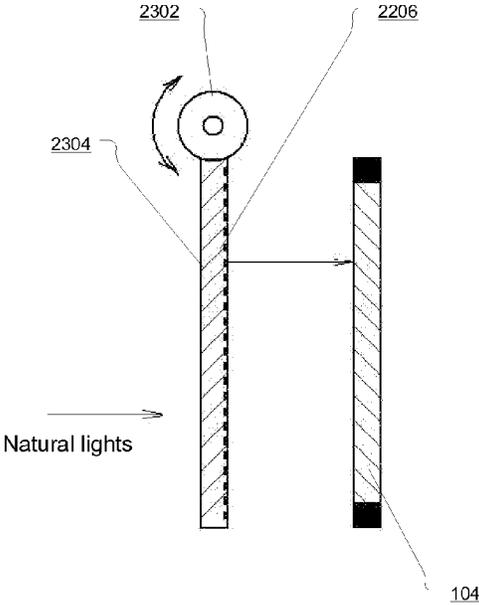


FIG. 23B

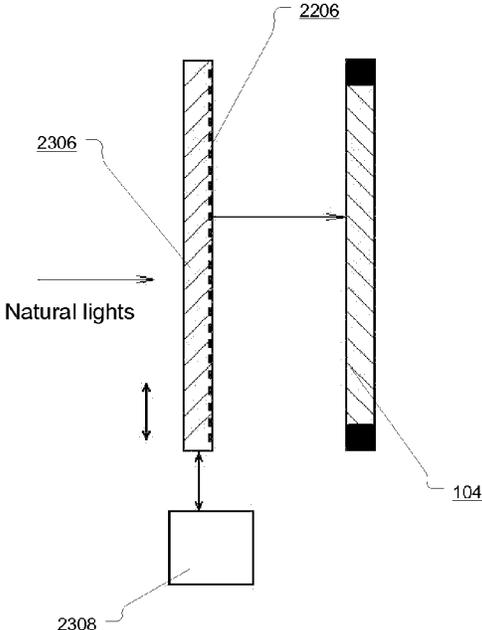


FIG. 23C

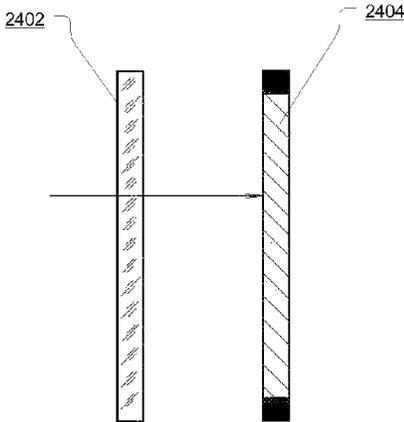


FIG. 24A

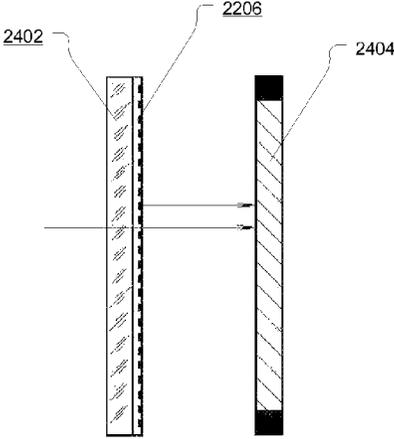


FIG. 24B

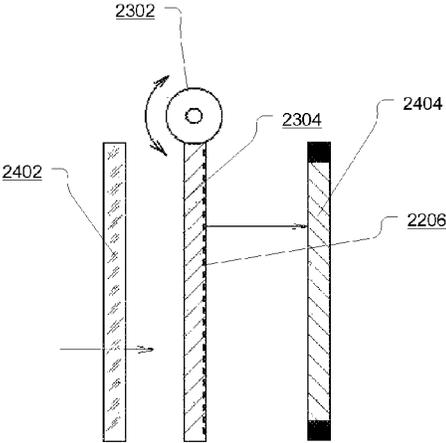


FIG. 24C

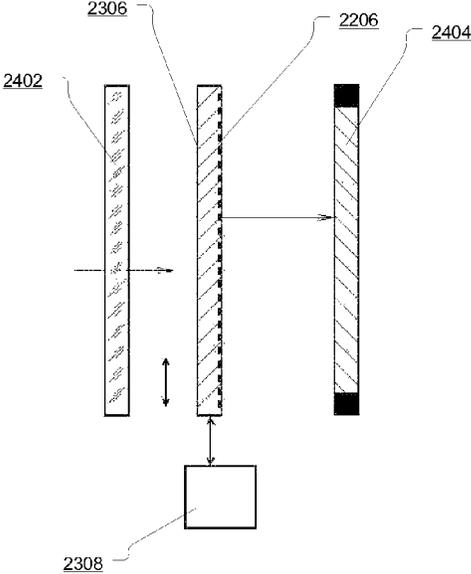


FIG. 24D

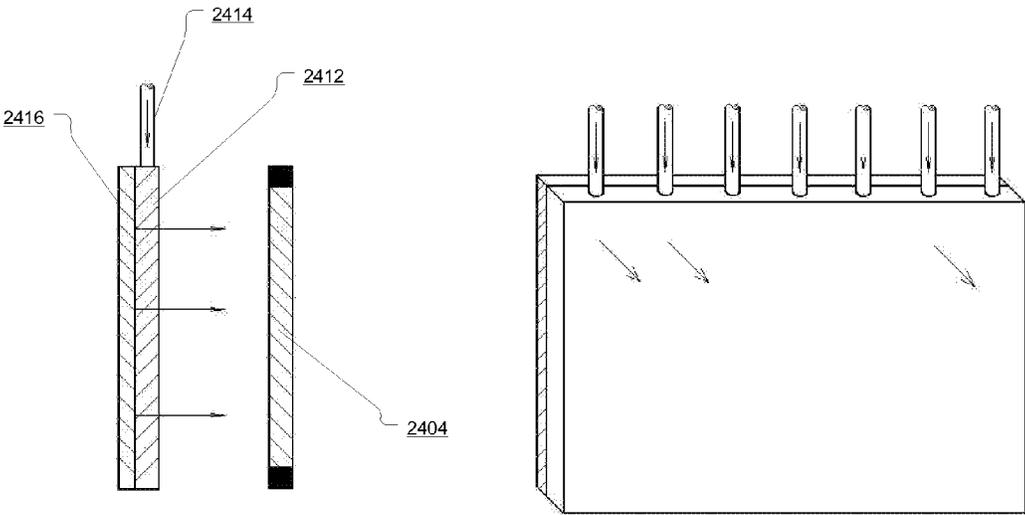


FIG. 24E

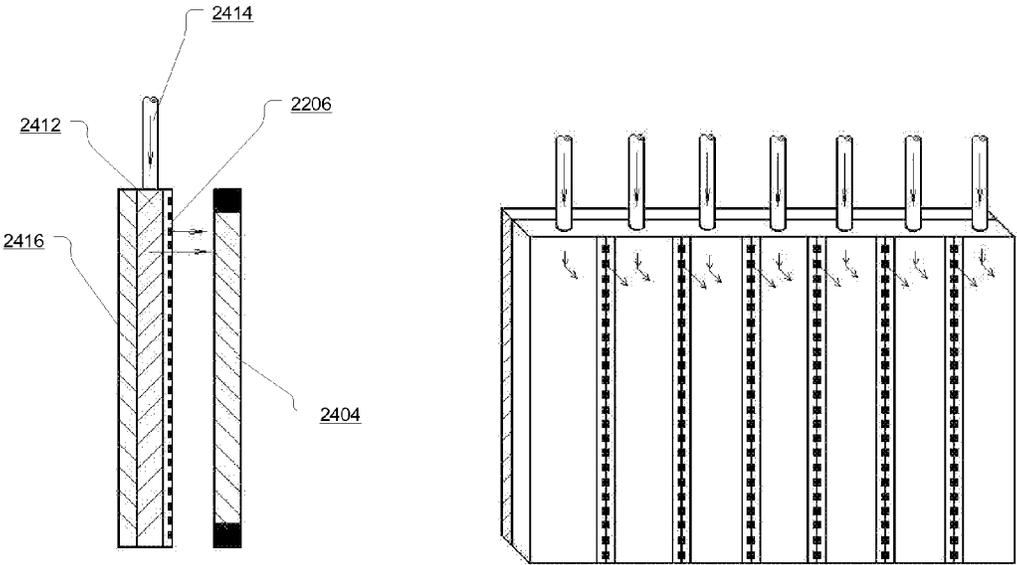


FIG. 24F

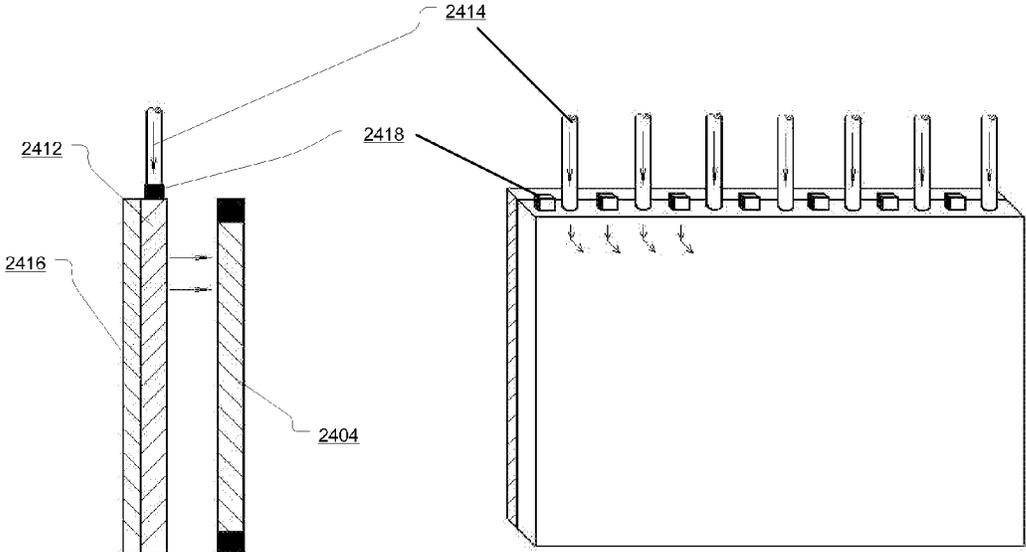


FIG. 24G

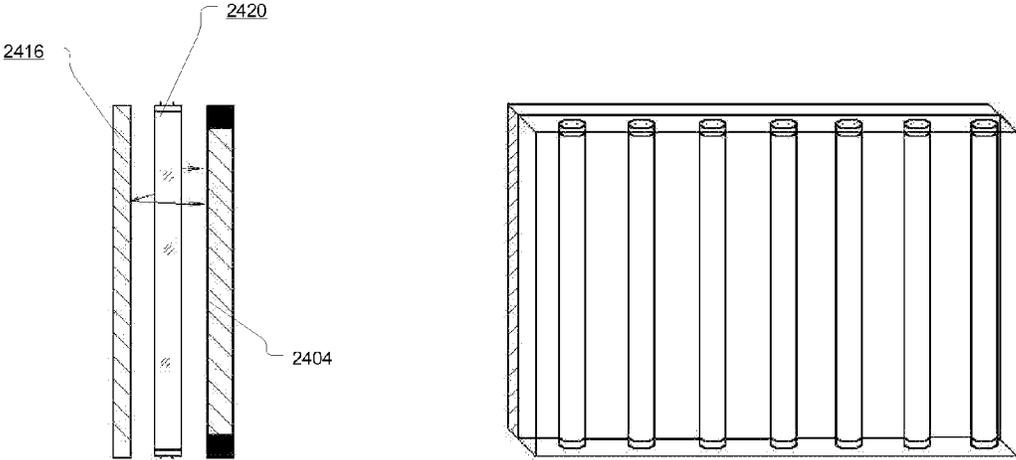


FIG. 24H

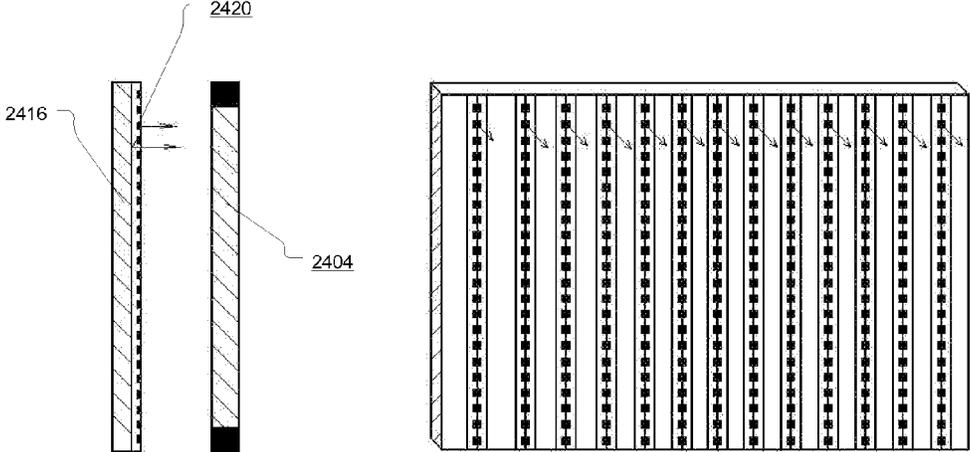


FIG. 24I

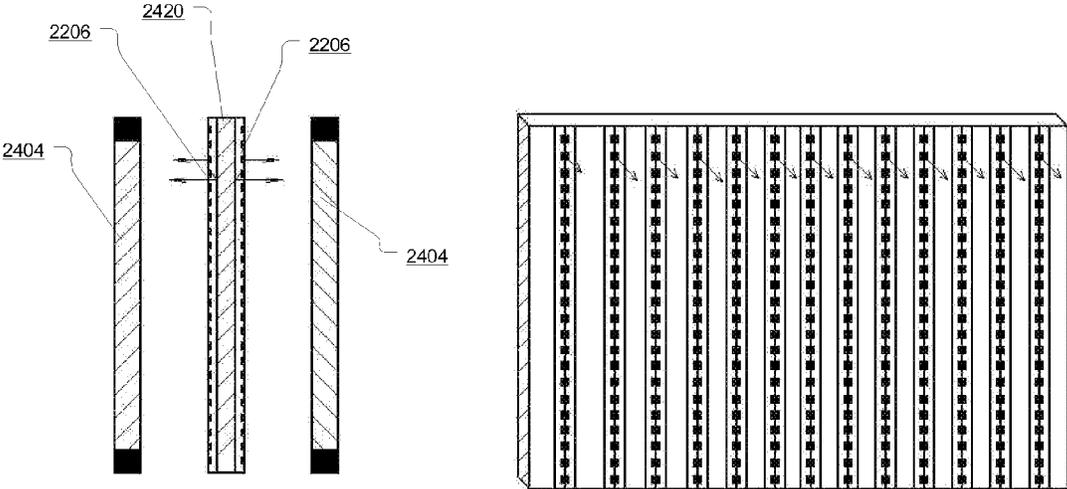


FIG. 24J

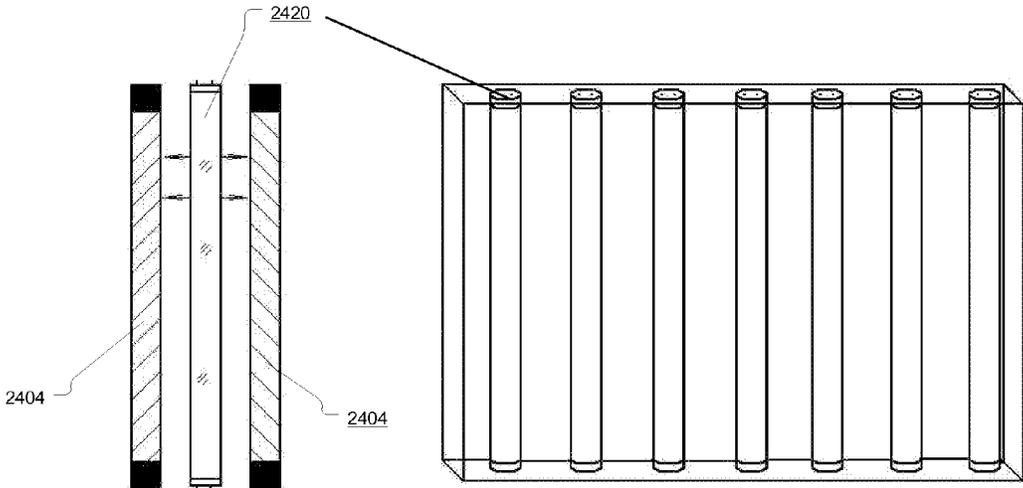


FIG. 24K

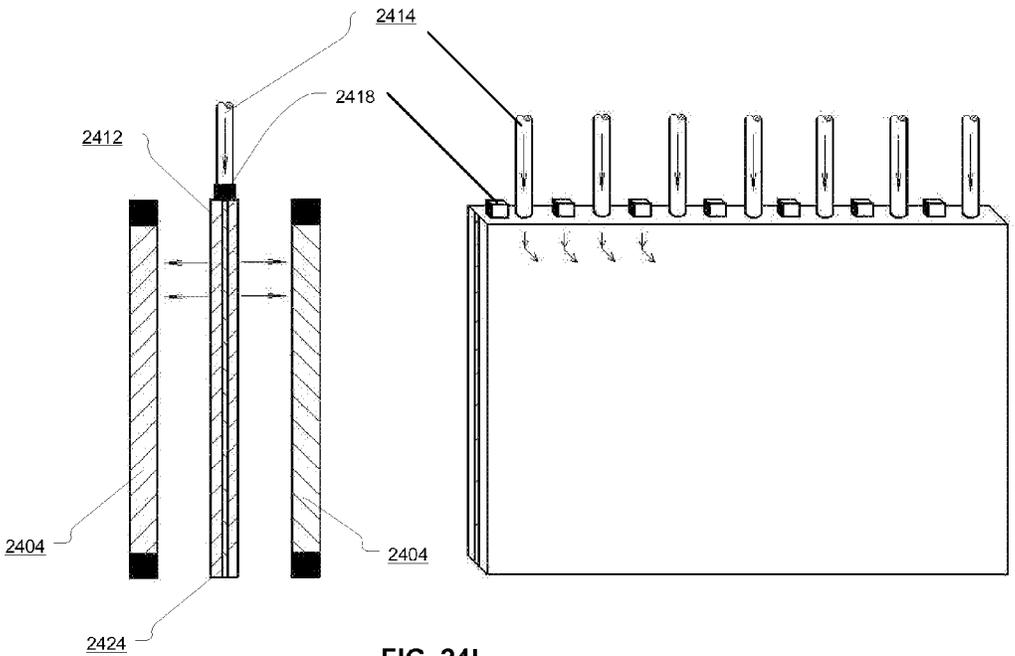


FIG. 24L

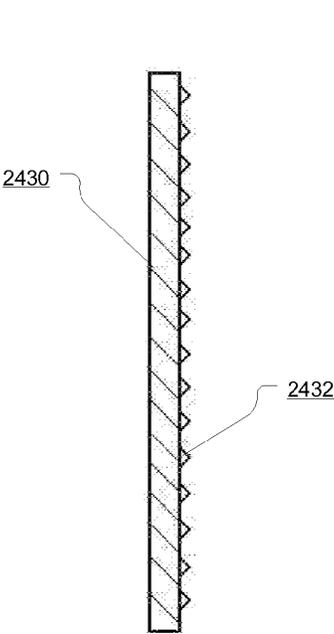


FIG. 25A

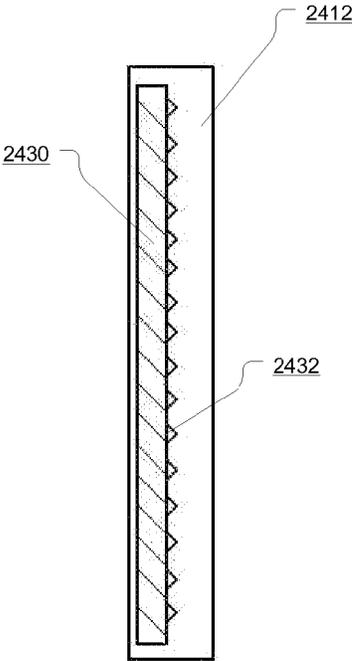


FIG. 25B

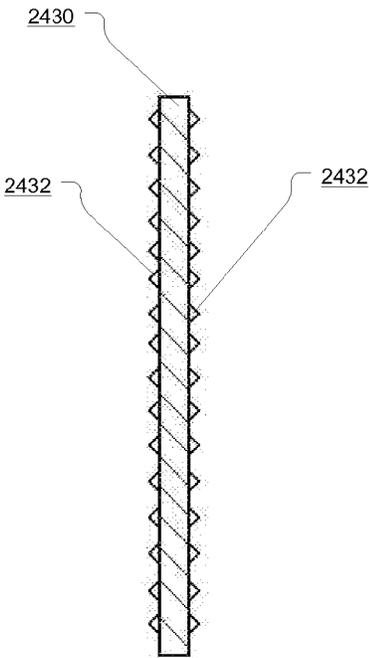


FIG. 25C

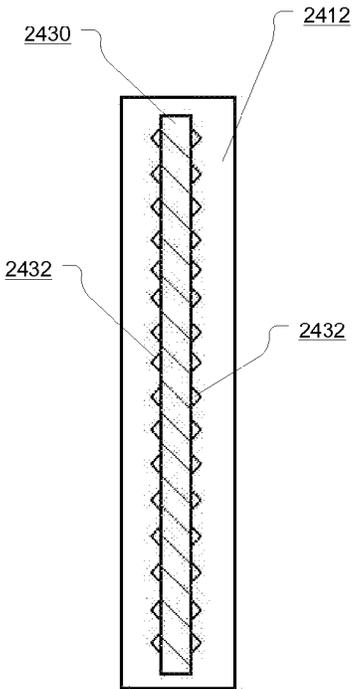


FIG. 25D

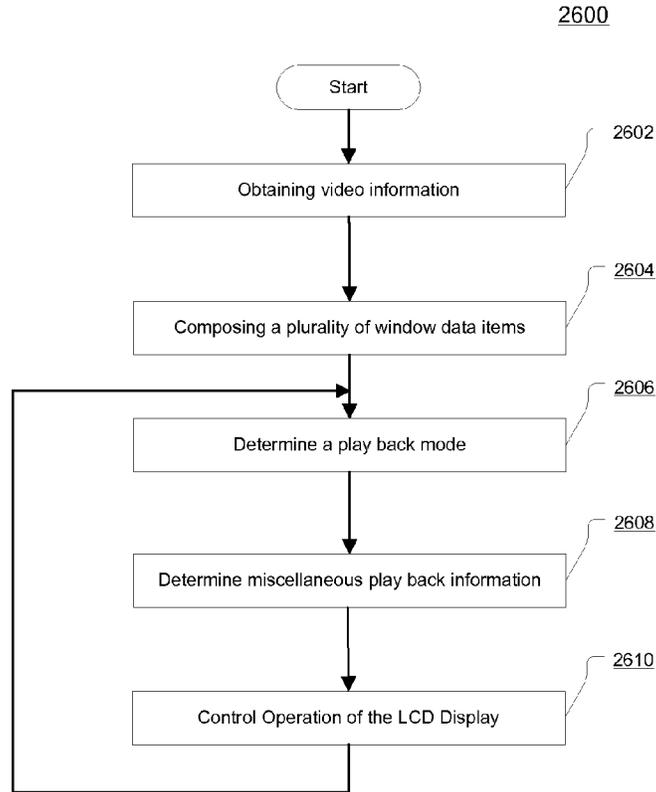


FIG. 26A

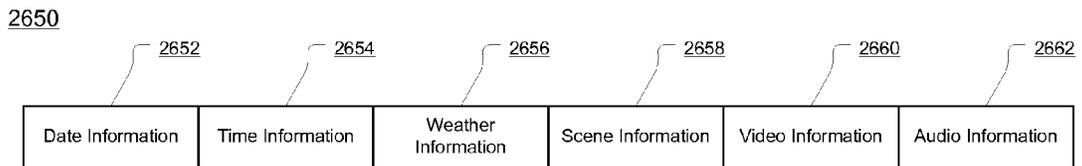


FIG. 26B

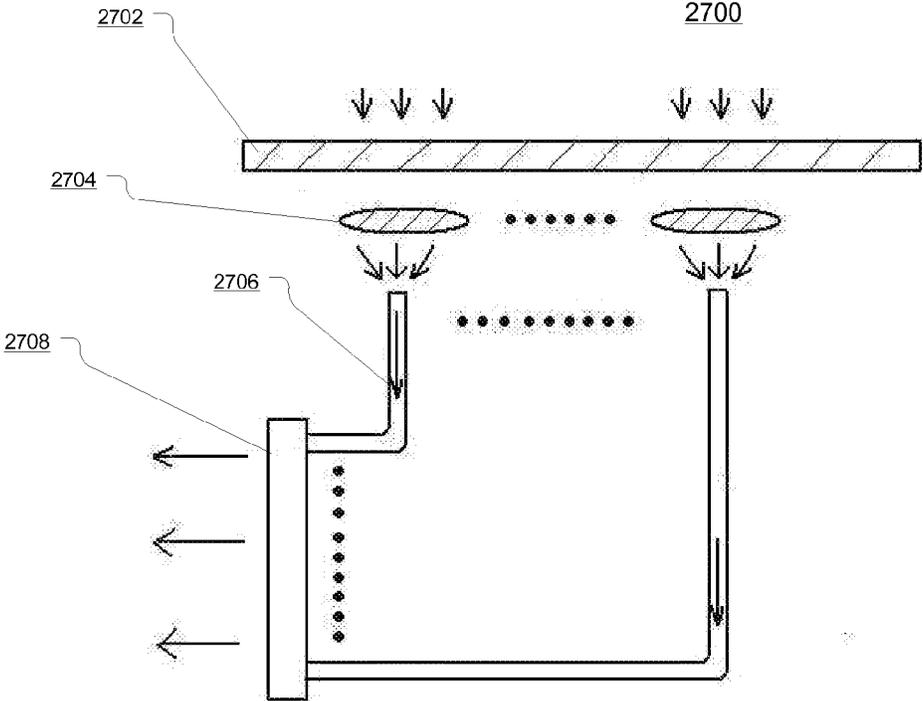


FIG. 27A

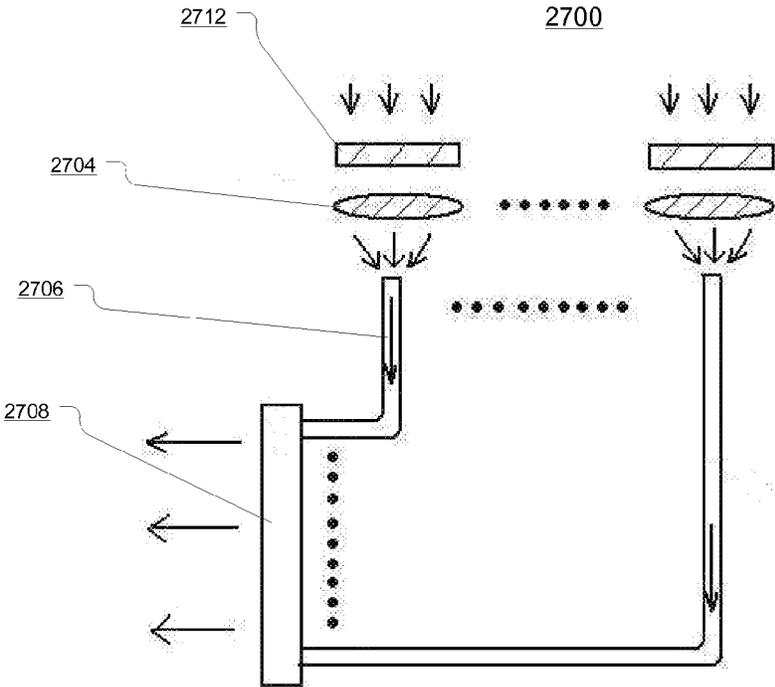


FIG. 27B

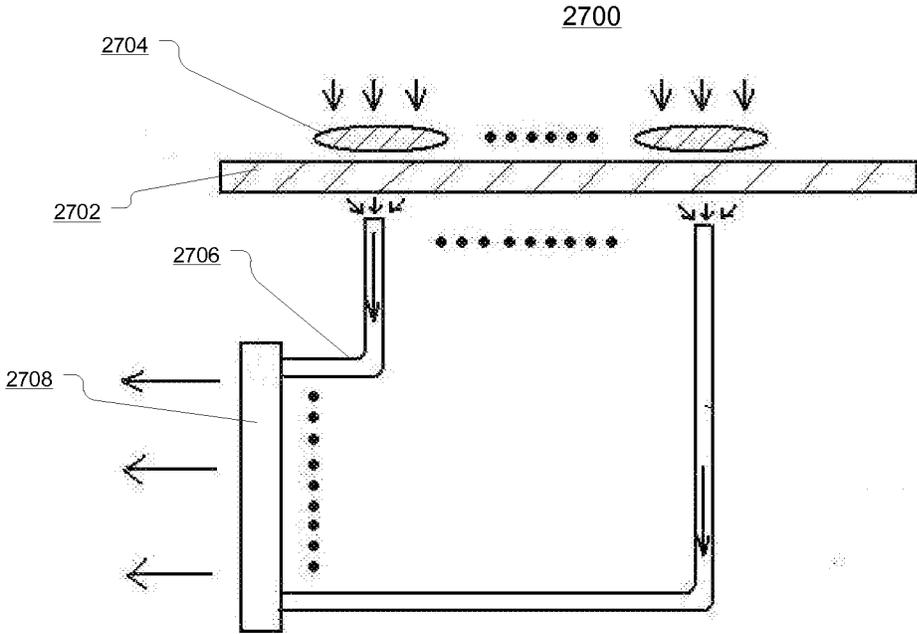


FIG. 27C

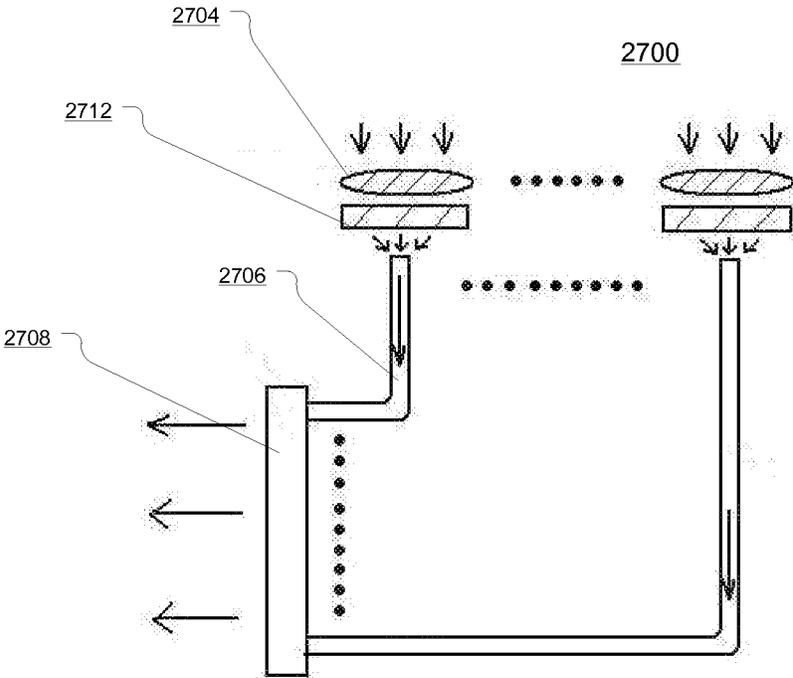


FIG. 27D

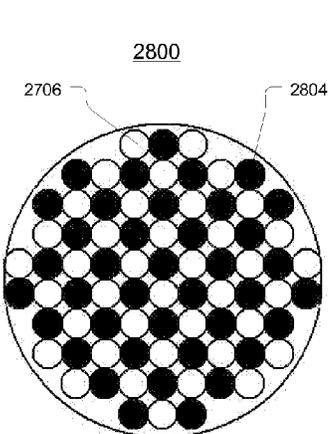


FIG. 28A

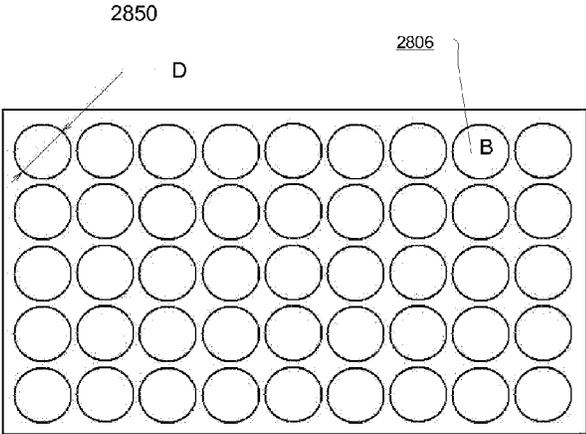


FIG. 28B

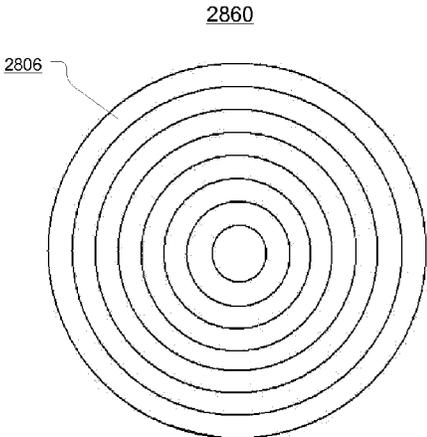


FIG. 28C

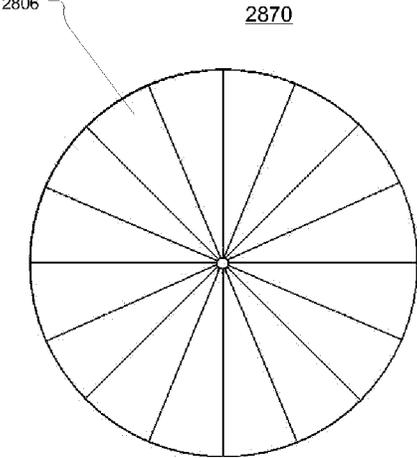


FIG. 28D

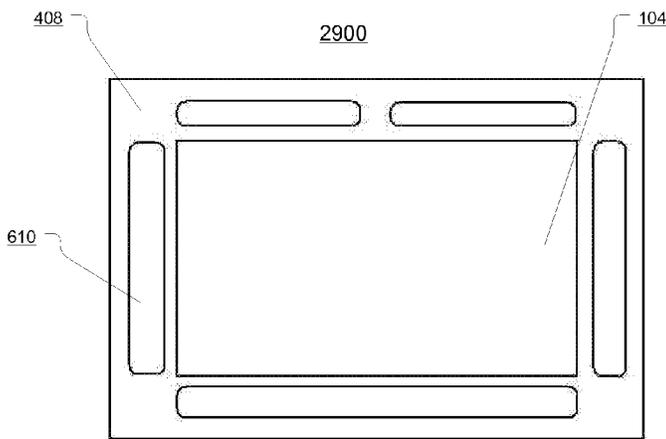


FIG. 29A

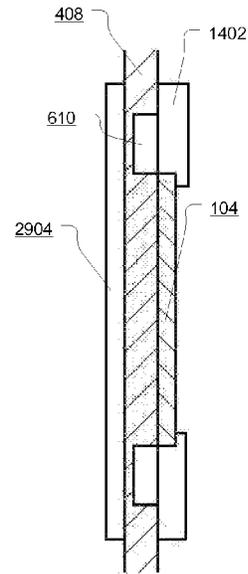


FIG. 29B

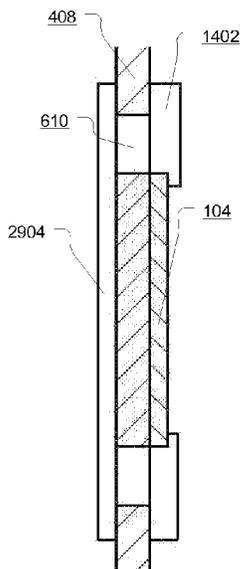


FIG. 29C

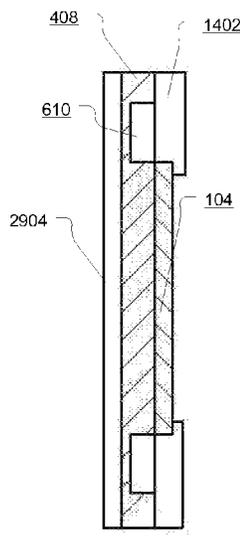


FIG. 29D

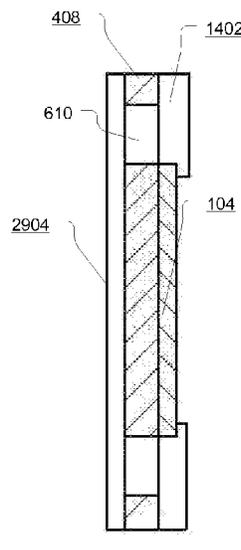


FIG. 29E

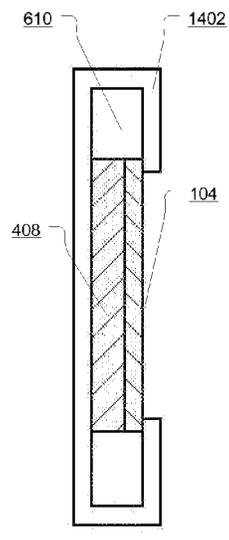


FIG. 29F

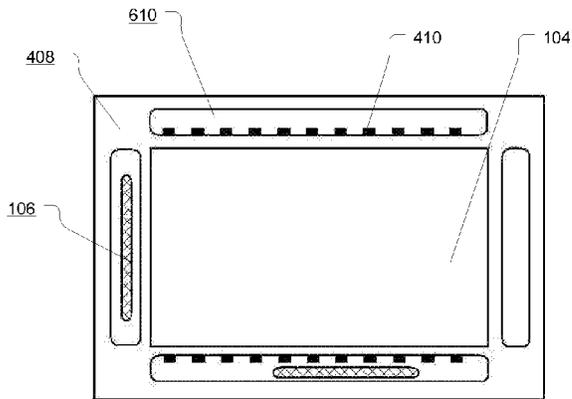


FIG. 30A

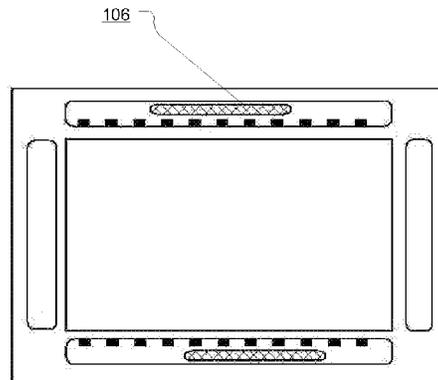


FIG. 30B

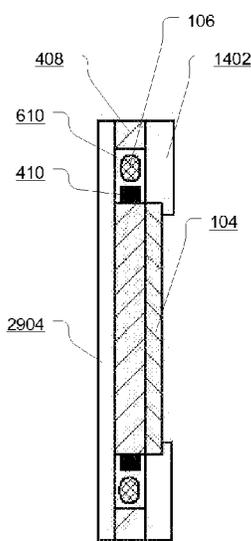


FIG. 30C

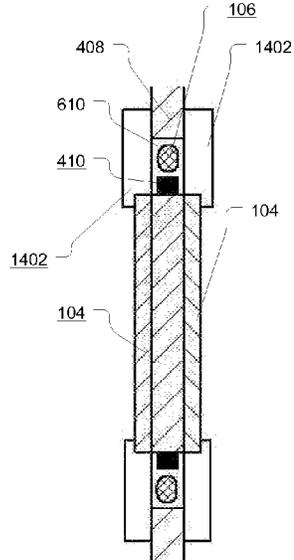


FIG. 30D

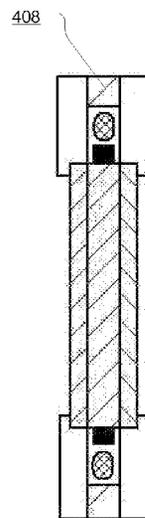


FIG. 30E

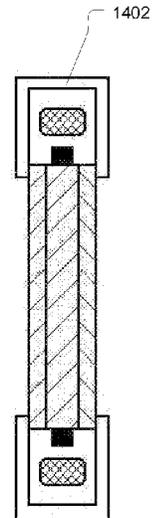


FIG. 30F

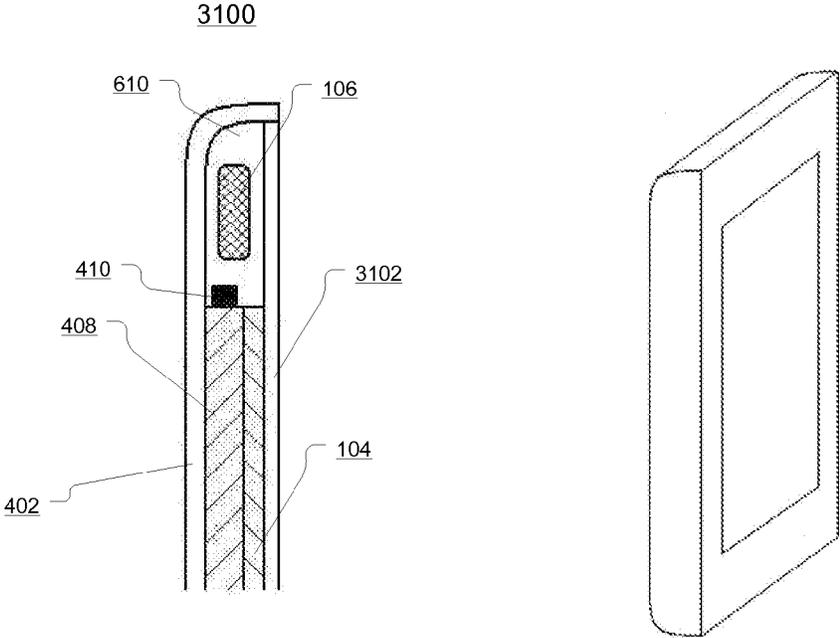


FIG. 31A

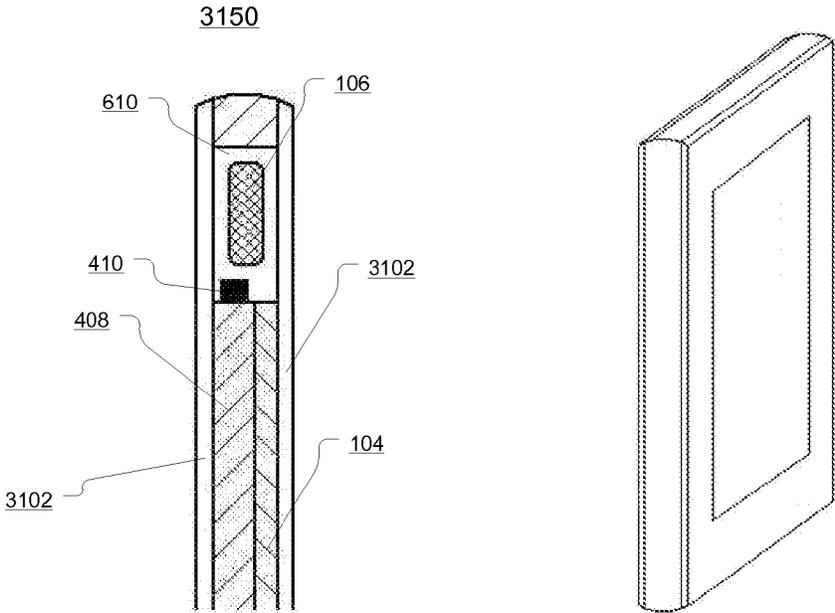


FIG. 31B

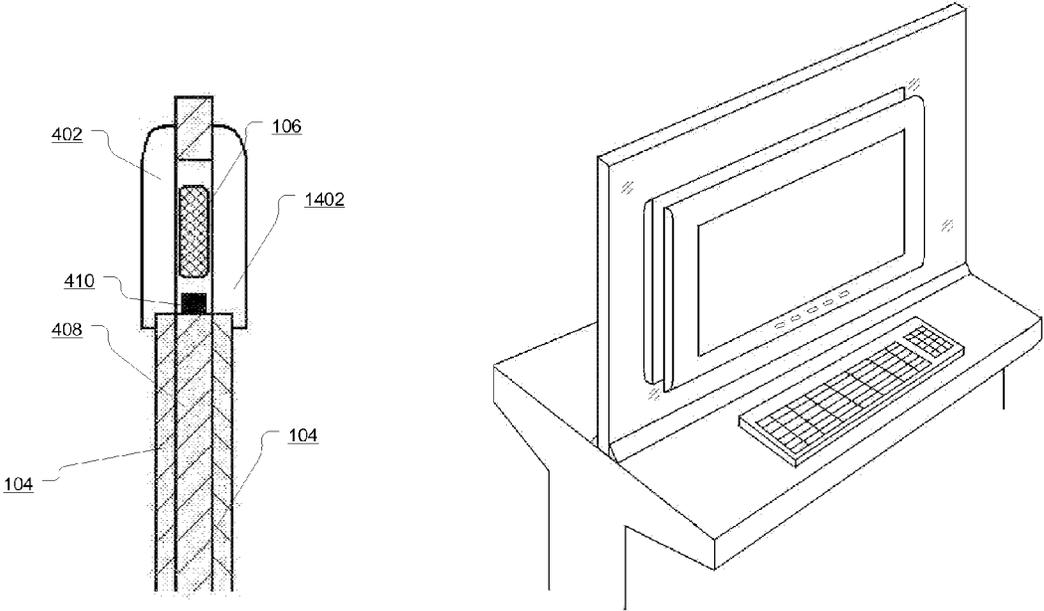


FIG. 32

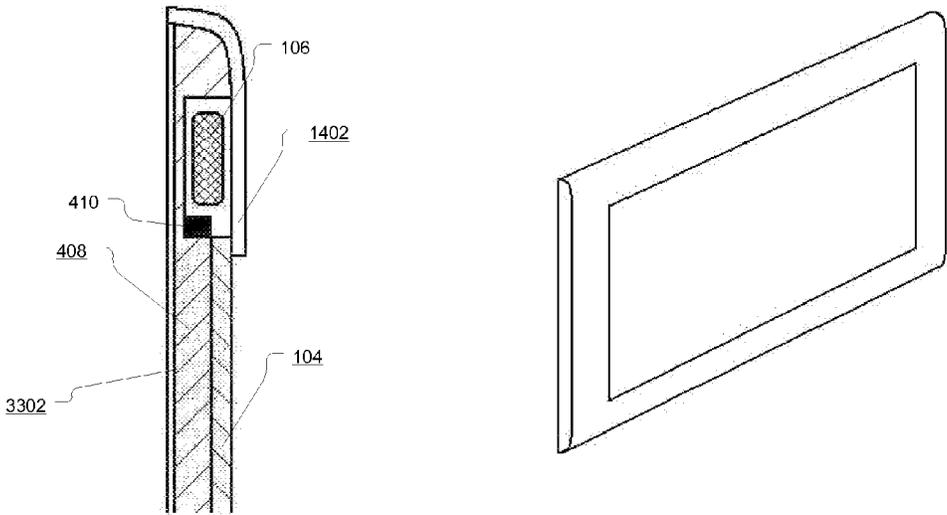


FIG. 33

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## LIQUID CRYSTAL DISPLAY (LCD) SYSTEM AND METHOD

### CROSS-REFERENCES TO RELATED APPLICATIONS

This is a continuation-in-part (CIP) application of U.S. patent application Ser. No. 12/768,638, filed on Apr. 27, 2010, the entire contents of which are incorporated herein by reference.

### FIELD OF THE INVENTION

This application generally relates to liquid crystal display (LCD) technology and, more particularly, to LCD systems with improved backlight mechanisms.

### BACKGROUND

A TV receiver or a computer monitor often employs a liquid crystal display (LCD) or a plasma display panel (PDP) to replace a cathode ray tube (CRT). Recently, the rapid advancement of the semiconductor techniques makes LCD panels, particularly color LCD panels more popular and less expensive.

An LCD panel is a passive display device in that the LCD panel displays light information signal that has been light-converted but does not itself emit light. Thus, an LCD device needs a light source such as a backlight unit. A conventional LCD device commonly uses a backlight unit employing a plurality of lamps to emit enough light to illuminate the LCD panel. However, a plurality of lamps not only consume a large amount of energy, but also limit the size, weight, and operational environment of the LCD device.

Some LCD devices use external light to improve the backlight unit. For example, published US patent application no. 2010/0073791 to Mahowald (the '791 application) discloses an apparatus for harnessing external light to illuminate a display screen of an electronic device. However, the '791 application explicitly addresses the problem where the external or ambient light is brighter than the illumination of the display screen by collecting external light to help illuminate the display screen. Therefore, the '791 application may not be able to overcome the shortcomings of the conventional LCD devices.

Further, demands for large and super-large display screens are increasing. Currently, many limitations exist in manufacturing, structural design, size, and transportation of those large and super-large display screens, and, thus, make producing and installing those large and super-large display screens costly. Conventional LCD display devices also integrate backlight sources with LCD screen, and may substantially increase the manufacturing cost of backlight sources when the size of the display screens increases. Cost of other components of the display screen may also increase.

Therefore, it would be beneficial to provide systems and methods employing natural light or external light as the light source to illuminate an LCD panel. The disclosed methods and systems are directed to solve one or more problems set forth above and other problems.

### BRIEF SUMMARY OF THE DISCLOSURE

One aspect of the present disclosure includes a liquid crystal display (LCD) system. The LCD system includes a light source and a self-contained display unit including at least a LCD panel and a light guide plate coupled together, wherein

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the light guide plate is configured to guide light from the light source to the LCD panel as backlight and to structurally support the LCD panel. Further, a plurality of pre-made hollow spaces are contained in the display unit configured to host components of the LCD system. The LCD system also includes a controller contained in the plurality of pre-made hollow spaces and coupled to the LCD panel to control the LCD panel such that the light passing through the light guide plate is used as backlight for operation of the LCD panel.

Another aspect of the present disclosure includes a method for an LCD system in an electronic window application. The method includes obtaining video images to be displayed on the LCD system to simulate a window. The method also includes composing a plurality of window data items based on the video images, and each window data item includes date information, time information, weather information, scene information, video information, and audio information. Further, the method includes determining a playback mode and controlling operation of the LCD system to play the window data items according to the playback mode to generate window sceneries.

Another aspect of the present disclosure includes an LCD system based signaling system. The signaling system includes one or more LCD panels configured to receive natural light, and a plurality of convex lenses coupled to the LCD panels to concentrate the received natural light. The signaling system also includes a plurality of optic fibers configured to receive the concentrated natural light at one end and to couple with a signaling panel at the other end such that the received light from the optic fiber is used to provide various signals on the signaling panel. Further, the signaling panel is turned on and off by controlling the LCD panels to allow or not allow the natural light passing through the LCD panels.

Another aspect of the present disclosure includes an LCD system, the LCD system includes a display system and a separate backlight system. The display system is without backlighting and capable of being coupled to a plurality of backlight sources. The separate backlight system is coupled to the display system to provide at least one of the plurality of backlight sources. Further, the display system includes at least a LCD panel, a light guide plate coupled to the LCD panel, and a control circuitry; the light guide plate is configured to guide light from the at least one of the plurality of backlight sources to the LCD panel as backlight and to structurally support the LCD panel; and the LCD panel is coupled to the light guide plate by a glue layer.

Other aspects of the present disclosure can be understood by those skilled in the art in light of the description, the claims, and the drawings of the present disclosure.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates an exemplary LCD system consistent with the disclosed embodiments;

FIG. 2 illustrates an exemplary controller of an LCD system consistent with the disclosed embodiments;

FIG. 3A illustrates an exemplary configuration of an LCD display consistent with the disclosed embodiments;

FIG. 3B illustrates another exemplary configuration of the LCD display consistent with the disclosed embodiments;

FIG. 3C illustrates another exemplary configuration of the LCD display consistent with the disclosed embodiments;

FIG. 4A illustrates an exemplary configuration of an LCD display consistent with the disclosed embodiments;

FIG. 4B illustrates another exemplary configuration of the LCD display consistent with the disclosed embodiments;

FIG. 5 illustrates an exemplary configuration of an LCD display consistent with the disclosed embodiments;

FIG. 6 illustrates an exemplary configuration of an LCD display consistent with the disclosed embodiments;

FIG. 7A illustrates an exemplary configuration of an LCD display consistent with the disclosed embodiments;

FIG. 7B illustrates another exemplary configuration of the LCD display consistent with the disclosed embodiments;

FIG. 7C illustrates another exemplary configuration of the LCD display consistent with the disclosed embodiments;

FIG. 8 illustrates an exemplary LED belt consistent with the disclosed embodiments;

FIG. 9A illustrates an exemplary configuration of an LED element consistent with the disclosed embodiments;

FIG. 9B illustrates another exemplary configuration of the LED element consistent with the disclosed embodiments;

FIG. 9C illustrates another exemplary configuration of the LED element consistent with the disclosed embodiments;

FIG. 9D illustrates another exemplary configuration of the LED element consistent with the disclosed embodiments;

FIG. 10 illustrates an exemplary configuration of an LCD display consistent with the disclosed embodiments;

FIG. 11 illustrates an exemplary configuration of an LCD display consistent with the disclosed embodiments;

FIG. 12 illustrates an exemplary operation process for an LCD system consistent with the disclosed embodiments;

FIG. 13 illustrates an exemplary control process for an LCD system consistent with the disclosed embodiments;

FIGS. 14A-14D illustrate exemplary installations of LCD panels consistent with the disclosed embodiments;

FIGS. 15A-15C illustrate exemplary configurations of a front frame consistent with the disclosed embodiments;

FIGS. 16A-16D illustrate exemplary configurations of a light guide plate consistent with the disclosed embodiments;

FIGS. 17A-17F illustrate other exemplary configurations of a front frame consistent with the disclosed embodiments;

FIGS. 18A-18H illustrate exemplary configurations associated with a front frame consistent with the disclosed embodiments;

FIGS. 19A-19B illustrate exemplary installations of display screens consistent with the disclosed embodiments;

FIGS. 20A-20B illustrate exemplary installations of control circuitry consistent with the disclosed embodiments;

FIGS. 21A-21B illustrate exemplary large display screen structures consistent with the disclosed embodiments;

FIGS. 22A-22D illustrate exemplary LED belts and configurations consistent with the disclosed embodiments;

FIGS. 23A-23C illustrate exemplary LED backlighting configurations consistent with the disclosed embodiments;

FIGS. 24A-24L illustrate exemplary configurations for arranging display systems and backlight systems consistent with the disclosed embodiments;

FIGS. 25A-25D illustrate exemplary light guide plate structures consistent with the disclosed embodiments;

FIG. 26A illustrates an exemplary electronic window process consistent with the disclosed embodiments;

FIG. 26B illustrates an exemplary window data item consistent with the disclosed embodiments;

FIGS. 27A-27D illustrate exemplary signaling systems consistent with the disclosed embodiments;

FIGS. 28A-28D illustrate exemplary signaling panel structures consistent with the disclosed embodiments;

FIGS. 29A-29F illustrate exemplary integrated display systems consistent with the disclosed embodiments;

FIGS. 30A-30F illustrate other exemplary integrated display systems consistent with the disclosed embodiments;

FIGS. 31A-31B illustrate exemplary portable computers consistent with the disclosed embodiments;

FIG. 32 illustrates an exemplary two-side display system consistent with the disclosed embodiments; and

FIG. 33 illustrates an exemplary attachable display system consistent with the disclosed embodiments.

#### DETAILED DESCRIPTION

Reference will now be made in detail to exemplary embodiments of the invention, which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

FIG. 1 illustrates an exemplary LCD system 100. As shown in FIG. 1, LCD system 100 includes a window glass 102, an LCD panel 104, and a controller 106. Other components may also be included. Although LCD system 100 as illustrated is based on LCD technology, any appropriate technology may be used and LCD system 100 is not limited to LCD technology.

Window glass 102 may refer to any appropriate type of light-passable plate, such as a glass plate for windows, walls, or doors, which allows natural light to pass through. For the purpose of illustration, windows may be used to associate with window glass 102. However, any type of appropriate structures may be used to associate with window glass 102, such as doors, walls, boards, or the like. Window glass 102 may be made of any appropriate transparent material or translucent material with certain degree of transparency to let certain amount of natural light pass through.

LCD panel 104 may include any appropriate type of LCD screen or any other type of passive display screen for displaying images, texts, videos, etc. Although only one LCD panel is shown, LCD panel 104 may include one or more LCD panels. LCD panel 104 is coupled to or mounted on window glass 102 to allow natural light pass LCD panel 104 through window glass 102 and to save space between LCD panel 104 and window glass 102. That is, window glass 102 not only passes light to illuminate LCD panel 104, but also structurally supports LCD panel 104. Various mechanisms may be used to couple LCD panel 104 to window glass 102. For example, LCD panel 104 may be coupled to window glass 102 using glue (not shown) or using mechanical fasten means such as screws (not shown). For the purpose of illustration, window glass 102 coupled with LCD panel 104 and other related components, if any, may be referred as an LCD display.

Further, LCD panel 104 is couple to controller 106. Although controller 106 is illustrated as a separate unit, certain part(s) or all of controller 106 may be integrated into LCD panel 104. Controller 106 may include any appropriate device or system for controlling LCD panel 104 and providing audio, video, and picture sources to LCD panel 104. FIG. 2 shows an exemplary block diagram of controller 106.

As shown in FIG. 2, controller 106 may include a CPU 202, a memory module 204, a video unit 206, a display drive 208, an interface unit 210, a communication unit 212, a power source 214, an audio unit 216, a supplemental light drive 218, an internal light source 220, an input unit 222, a solar panel battery 224, and speaker 226. All these devices/units are listed for illustration purposes, certain devices/units may be omitted and other devices may be added without departing from the principles of the present invention. Further, a bus 228 is included to allow various devices/units coupled with CPU 202 for operation.

CPU 202 may include any appropriate type of general purpose microprocessor, digital signal processor or micro-

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controller. Memory module **204** may include one or more memory devices including, but not limited to, a ROM, a flash memory, a dynamic RAM, and a static RAM. Further, memory module **204** may include other storage devices such as hard disks, storage cards and disks. For example, memory module **204** may also include universal serial bus (USB) storage cards, secure digital (SD) storage cards, digital versatile disc (DVD) drive, etc. Memory module **204** may be configured to store information used by CPU **202**. Memory module **204** may also be configured to store audio, video, and text information to be displayed, and driver software and upgrade software for storage devices.

Video unit **206** may include any appropriate circuitry to provide video or image information to be displayed by LCD panel **104**, and display drive **208** may include circuitry to drive or control LCD panel **104**. Interface unit **210** may be used for CPU **202** to interface with other devices or components, either internal or external. Further, communication unit **212** may include any appropriate type of network adaptor capable of communicating with other computer systems based on one or more communication protocols. For example, communication unit **212** may include a wireless communication unit communicating with LCD panel wirelessly.

Power source **214** may include any appropriate direct current (DC) or alternating current (AC) power supply for providing power to controller **106**. Audio unit **216** may be provided to decode or generate audio information and to input the audio information to speaker **226**. Further, supplemental light drive **218** may include any appropriate circuitry to drive light sources/units used for supplementing natural light, and internal light source **220** may be optionally provided to include any appropriate light devices, such as light emitting diodes (LEDs), to illuminate LCD panel **104**.

Input unit **222** may include any appropriate type of input device, such as a key board, a touch screen or touch pad, a mouse, or a remote control, to allow a user of LCD system **100** to interact with LCD system **100**. Solar panel battery **224** may include any appropriate type of battery based on solar energy. Further, bus **228** may include one or more control and/or data buses to couple various devices/units together for operation.

Returning to FIG. 1, natural light passing through window glass **102** illuminates LCD panel, i.e., acts as backlight for LCD panel **104**. Using natural light as the backlight may not only save a significant amount of energy and space, but also improve image quality displayed on LCD panel **104** in that natural light may have a wider spectrum than artificial light such that images on an LCD panel with natural light backlight may appear more colorful and realistic looking. In operation, various configurations or setups for coupling window glass **102** and LCD panel **104** may be provided for using natural light as the backlight for LCD panel **104**. FIG. 3A illustrates an exemplary configuration of window glass **102** and LCD panel **104** forming an LCD display **300**.

As shown in FIG. 3A, window glass **102** and LCD panel **104** are coupled by using coupler **302**. As explained previously, coupler **302** may be any appropriate chemical means or mechanical means or both to couple LCD panel **104** to window glass **102** closely. Although coupler **302** is shown on one side, coupler **302** may include any appropriate shape or structure, such as a continuous frame, or a discontinuous support structure.

Further, concentrator film **304** and diffuser film **306** are coupled or placed between window glass **102** and LCD panel **104**. Concentrator film **304** may include any appropriate type of film or thin material for concentrating natural light; and diffuser film **306** may include any appropriate type of film or

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thin material for diffusing natural light passing through to evenly illuminate LCD panel **104**.

Although concentrator film **304** and diffuser film **306** are both used for illustration purposes, either concentrator film **304** or diffuser film **306** alone may be used in certain embodiments. Further, other materials providing similar functionalities may also be used instead of concentrator film **304** and diffuser film **306**. For example, a diffuser glass plate may be used in place of concentrator film **304** and diffuser film **306**, and the diffuser glass plate may be closely coupled between window glass **102** and LCD panel **104**. In certain other embodiments, LCD panel **104** may be directly coupled to window glass **102** without concentrator film **304** and/or diffuser film **306**.

A wheeling device **308** may be provided to deploy and retract concentrator film **304** and diffuser film **306**. Wheeling device **308** may include any type of device that, manually or automatically under the control of controller **106**, extends concentrator film **304** and diffuser film **306** to be positioned between window glass **102** and LCD panel **104** and to cover LCD panel **104**. Wheeling device **308** may also retrieve concentrator film **304** and diffuser film **306** such that natural light passing through window glass **102** illuminates LCD panel **104** without passing through concentrator film **304** and diffuser film **306**.

FIG. 3B illustrates another exemplary configuration of LCD display **300**. As shown in FIG. 3B, LCD display **300** includes the same components as in FIG. 3A, except wheeling device **308**. Thus, concentrator film **304** and diffuser film **306** are positioned between window glass **102** and LCD panel **104** without the capability of being retrieved to allow natural light pass through window glass **102** to directly illuminate LCD panel **104**.

FIG. 3C illustrates another exemplary configuration of LCD display **300**. As shown in FIG. 3C, LCD display **300** includes window glass **102**, LCD panel **104**, and coupler **302**. Further, LCD display **300** may include a transparency control unit **310**. Transparency control unit **310** may include any appropriate type of structure, such as a film or a glass plate, whose transparency may be controlled by electricity current or voltage applied to the structure. By changing the applied current or voltage, the transparency of transparency control unit **310** may be controlled. Further, transparency control unit **310** may also diffuse natural light passing through window glass **102** to evenly illuminate LCD panel **104**.

FIG. 4A illustrates an exemplary configuration of window glass **102** and LCD panel **104** forming an LCD display **400**. As shown in FIG. 4A, glass **102** and LCD panel **104** are coupled by using coupler **302**, and concentrator film **304** and diffuser film **306** are placed between window glass **102** and LCD panel **104**. Further, a frame **402** is coupled to window glass **102** on the side opposite to LCD panel **104**. A reflector **404** is coupled to frame **402** via coupler **406** such that reflector **404** may be rotated to and from frame **402**.

Reflector **404** may include a reflecting surface such that reflector **404** may reflect natural light to window glass **102** and to increase amount of natural light passing through window glass **102**. Coupler **406** may include any appropriate structure such that reflector **404** may rotate manually or automatically along an axis of coupler **406** with respect to frame **402**, such as a motor or a hinge. For example, reflector **404** may rotate to a closed position, i.e., reflector **404** fits into frame **402**, or at any angle with respect to frame **402** such that the light reflected to window glass **102** is suitable for properly illuminating LCD panel **104**. Reflector **404** may be used to improve or supplement natural light passing through window glass **102**.

Further, reflector **404** may include a light-guide **408** and a light source **410**. Light-guide **408** may include any appropriate material to guide light emitted by light source **410** to pass through window glass **102**. Light source **410** may include one or more lamps or LEDs to supplement or replace natural light. For example, if natural light or natural light improved by light reflected by reflector **404** is sufficient to illuminate LCD panel **104**, light source **410** might remain turned off. However, if the natural light is not sufficient, light source **410** may emit light to supplement or replace the natural light to illuminate LCD panel **104**. When reflector **404** is rotated to the closed position, no natural light passes through window glass **102** and light source **410** becomes the only light source to illuminate LCD panel **104**.

In certain embodiments, window glass **102** may be omitted. LCD panel **104** may be coupled to frame **402** via coupler **302**. That is, LCD panel **104** coupled with frame **402** may act as a window or the like, when mounted on window frames, walls, doors, and similar structures.

FIG. **4B** illustrates another exemplary configuration of LCD display **400**. As shown in FIG. **4B**, the LCD display includes the same components as in FIG. **4A**, except that light-guide **408** and light source **410** are coupled to frame **402**. Light emitted from light source **410**, via light-guide **408**, may directly pass through window glass **102** in straight angle (e.g., about 90 degrees) when supplementing the natural light. Further, in certain embodiments, window glass **102** may coincide with light-guide **408**. In certain other embodiments, light-guide **408** and/or window glass **102** may contain a matte surface such that concentrator film **304** and/or diffuser film **306** may be omitted.

FIG. **5** illustrates an exemplary configuration of window glass **102** and LCD panel **104** forming an LCD display **500**. As shown in FIG. **5**, glass **102** and LCD panel **104** are coupled by using coupler **302**, and concentrator film **304** and diffuser film **306** are placed between window glass **102** and LCD panel **104**. A frame **402** is coupled to window glass **102** on the side opposite to LCD panel **104**.

A light-guide **408** and a light source **410** are coupled to frame **402**. As previously explained, light-guide **408** guides light emitted by light source **410** to pass through window glass **102**. Further, a reflecting film **502** may be positioned to cover light-guide **408**. A wheeling unit **504** may be provided to deploy and retrieve reflecting film **502**, manually or automatically under the control of controller **106**. When natural light is sufficient to illuminate LCD panel **104**, light source **410** may be turned off, and wheeling unit **504** retrieves reflecting film **502** to allow natural light to pass window glass **102** to illuminate LCD panel **104**. On the other hand, when natural light is not sufficient to illuminate LCD panel **104**, light source **410** may be turned on, and wheeling unit **504** deploys reflecting film **502** to reflect light emitted from light source **410** to improve efficiency of light source **410**.

FIG. **6** illustrates an exemplary configuration of window glass **102** and LCD panel **104** forming an LCD display **600**. As shown in FIG. **6**, LCD display **600** includes window glass **102**, LCD panel **104**, coupler **302**, concentrator film **304**, diffuser film **306**, frame **402**, light-guide **408**, and light source **410**, as explained previously. Further, a single-direction film **602** may be positioned above light-guide **408** and may also be coupled to frame **402**.

Single-direction film **602** may include any optical thin material that allows light pass through from one direction only and may reflect light from a reverse direction, such as a one-way mirror or any type of single direction transmission film or thin plate. Natural light may pass through single-direction film **602** to illuminate LCD panel **104** without turn-

ing on light source **410**. However, when natural light is not sufficient, light source **410** may be turned on, light emitted from light source **410** may be provided by concentrator film **304** to illuminate LCD panel **104**. Further, some light emitted from light source **410** may be reflected back by single-direction film **602** to improve the illumination of LCD panel **104**.

FIG. **7A** illustrates an exemplary configuration of window glass **102** and LCD panel **104** forming an LCD display **700**. As shown in FIG. **7A**, LCD display **700** may include window glass **102**, LCD panel **104**, coupler **302**, concentrator film **304**, diffuser film **306**, frame **402**, and light-guide **408**, as explained previously. Further, a plurality of LEDs **702** may be attached to light-guide **408**. Natural light may pass through light-guide **408** to illuminate LCD panel **104** without turning on LEDs **702**. However, when natural light is not sufficient, LEDs **702** may be turned on, light emitted from LEDs **702** may illuminate LCD panel **104** to supplement or replace natural light.

FIG. **7B** and FIG. **7C** illustrate simplified configurations from that in FIG. **7A**. As shown in FIG. **7B**, LEDs **702** are attached to the outside of window glass **102** directly, without frame **402** and light-guide **408**, to provide light source to supplement or replace natural light. As shown in FIG. **7C**, LEDs **702** are attached to the inside of window glass **102** directly, without frame **402** and light-guide **408**, to provide a light source to supplement or replace natural light.

The plurality of LEDs **702** may be arranged in any appropriate ways. FIG. **8** illustrates an exemplary LED belt **800** for arranging LEDs. As shown in FIG. **8**, LED belt **800** includes a plurality of LED elements **802**, transparent film **804**, and electrically conductive lines **806**. Each LED element **802** may include one or more LEDs for illuminating LCD panel **104**. Electrically conductive lines **806** are provided to connect the plurality of LED elements to an electricity current source (not shown). Electrically conductive lines **806** may include any appropriate electrically conductive materials for connecting the plurality of LED elements, such as metal wires or transparent conductors (e.g., electrically conductive glue).

Further, LED element **802** may include one or more LEDs, including LEDs emitting white light and LEDs emitting various color light, such as red, blue, and green light. FIGS. **9A**, **9B**, **9C**, and **9D** illustrates exemplary LED element configurations. More particularly, FIG. **9A** illustrates that an LED element **802** includes a single LED **902**. FIG. **9B** illustrates that an LED element **802** includes a plurality of LEDs **904** connected in parallel. Although three LEDs are shown, any number of LEDs may be used. FIG. **9C** illustrates that an LED element **802** includes a plurality of LEDs **906** connected in series. Again, although three LEDs are shown, any number of LEDs may be used. Finally, FIG. **9D** illustrates that an LED element **802** includes a plurality LEDs **908** connected in parallel and in series. Although FIG. **9D** shows two LEDs are connected in series and three series of LEDs are connected in parallel, any number of LEDs may be connected in parallel and/or in series.

For example, FIGS. **22A** and **22B** illustrate exemplary serially connected LED belts. As shown in FIG. **22A**, LED belt **2202** includes a series of LED elements **802** connected in serial. In FIG. **22B**, LED belt **2204** includes a series of LED elements each containing three light source **802(r)**, **802(g)**, and **802(b)** for red, green, and blue light elements, respectively, such that a full color backlight may be formed.

Further, the LED belts (e.g., **800**, **2202**, and **2204**, etc.) may be glued to light guide plate **408**. FIG. **22C** shows an exemplary light belt configuration. As shown in FIG. **22C**, a plurality of LED belts **2206** are glued to light guide plate **408**. Because the LED belts are made of transparent materials,

natural light can pass through light guide plate **408** and LED belts **2206** for backlighting purposes. As shown in FIG. **22D**, a plurality of LED belts **2206** can also be glued to a reflector plate **2208**, because natural light cannot pass through the reflector plate **2208**, only LED belts **2206** is used for back-

lighting. Because the flexibility of the various LED belts, those LED belts may be arranged in many different ways to fit display screens of different sizes and different backlighting systems. Further, the density of the LED in the belts or of the LED belts may be adjusted to achieve desired brightness. For example, FIG. **23A** shows a plurality of LED belts being arranged on a large size light guide plate or reflector plate to provide back-

lighting. In FIG. **23B**, LED belts **2206** are attached on a flexible light reflecting sheet material **2304**, and sheet material **2304** is controlled by a wheeling device **2302**. When natural light is sufficient for providing backlighting to LCD panel **104**, wheeling device **2302** may be controlled to retract sheet material **2304** such that the natural light is used for backlighting. However, when the natural light is not sufficient for providing backlighting to LCD panel **104**, wheeling device **2302** may be controlled to deploy sheet material **2304** such that the LED belts **2206** are used for backlighting, supplementing or replacing the natural light.

Further, in FIG. **23C**, LED belts **2206** are arranged on a light reflecting plate **2306**, and the light reflecting plate **2306** is controlled by an automatic mechanism **2308** for moving the plate **2306** in a vertical or horizontal direction, similar to an automatic window in an automobile. When natural light is sufficient for providing backlighting to LCD panel **104**, automatic mechanism **2308** may be controlled to move plate **2306** to uncover LCD panel **104** such that the natural light is used for backlighting. However, when natural light is not sufficient for providing backlighting to LCD panel **104**, automatic mechanism **2308** may be controlled to move plate **2306** to cover LCD panel **104** such that the LED belts **2206** are used for backlighting, supplementing or replacing the natural light.

FIG. **10** illustrates an exemplary configuration of an LCD display **1000**. As shown in FIG. **10**, LCD display **1000** includes a light-guide **1002** and an LCD panel **1004** on one side of LCD display **1000**, a light-guide **1006** and an LCD panel **1008** on the other side of LCD display **1000**, and a reflecting film **1010**. Light-guide **1002** and light-guide **1006** may be coupled together, and may include any appropriate structure such as a plate. Reflecting film **1010** may be placed between light-guide **1002** and light-guide **1006**. Further, LCD display **1000** also includes a lens unit **1012** coupled to light-guide **1002** and light-guide **1006**.

Lens unit **1012** may include any material and structure suitable collecting natural light **1014** and pass to light-guides **1002** and **1006**. Although not shown, lens unit **1012** may be coupled to light-guide **1002** and light-guide **1006** via any appropriate means, such as direct coupling or optical fiber coupling. If optical fiber coupling is used, lens unit **1012** may be placed remotely and passes natural light through optical fibers to light-guides **1002** and **1006**.

Natural light collected by lens unit **1012** passes through light-guides **1002** and **1006** to illuminate LCD panels **1004** and **1008**, respectively. Reflecting film **1010** also reflects natural light back to LCD panels **1004** and **1008**. Although two light-guides and LCD panels are illustrated in FIG. **10**, a single-sided light-guide and LCD panel may also be used. Further, LEDs (not shown) may also be provided to supplement natural light by, as explained previously, attaching to a side of light-guide **1002** or **1006** or both.

In certain embodiments, light guide **1002** and light-guide **1006** may be pressed, molded, welded, or adhered into a

single light-guide, while reflecting film **1010** may also be pressed, molded, welded, or adhered into the single light-guide. Further, in certain other embodiments used in an environment with strong natural light, reflecting film **1010** may be omitted in the single light-guide.

FIG. **11** illustrates an exemplary configuration of an LCD display **1100**. As shown in FIG. **11**, LCD display **1100** includes window glass **102**, LCD panel **104**, and a base **1106**. Window glass **102** may also include any appropriate transparent or translucent material for passing natural light to relatively evenly illuminate LCD panel **104**. For example, window glass **102** may include a diffuser glass or the like. LCD panel **104** may include one or more LCD panels as explained previously. Base **1106** may include any appropriate structure configured to support window glass **102** and LCD panel **104** and any other applicable components. Natural light pass through window glass **102** to illuminate LCD panel **104**.

Further, LCD display **1100** may also include one or more projection lamps **1108** to emit light to supplement natural light when natural light is not sufficient, such as at night or in an environment or weather with insufficient ambient light. One or more support beams **1110** are coupled to base **1106** at one end and to one or more lamps at the other end to support one or more lamps **1108**. Lamps **1108** and support beams **1110** are configured in certain ways such that light **1112** emitted from lamps **1108** illuminates about entire area of window glass **102** relatively evenly. Other structures may also be used.

The above various configurations of LCD displays are described for illustration purposes. The various configurations may be used interchangeably and/or may be used in combination. For example, mechanisms of coupling window glass **102** and LCD panel **104** and of supplementing natural light in various configurations may be used in different configurations and/or may be combined in a single configuration.

Returning to FIG. **1**, controller **106** may automatically control LCD system **100** in operation. In certain embodiments, because natural light is used to illuminate LCD panel **104**, the amount of energy, circuitry, and space may be saved such that controller **106** may be fully integrated into LCD panel **104** without external power sources. Thus, LCD system **100** may be deployed in a self-contained manner, perhaps with a solar energy unit for supplying a small amount of power for system operation.

In operation, controller **106** and, more particularly, CPU **202** may execute computer instructions to perform certain actions to control operation of LCD system **100**. FIG. **12** illustrates an exemplary process **1200** performed by controller **106** or, more specifically, by CPU **202** of controller **106**.

As shown in FIG. **12**, in operation, CPU **202** may determine LCD display configuration (**1202**). The configuration may include information about various LCD display configurations explained previously, such as types and mechanisms of supplemental light, and operation parameters for natural light operation (i.e., natural light as the only light source to illuminate an LCD panel) and natural light and supplemental light operation (i.e., supplemental light is provided to illuminate the LCD panel), etc. CPU **202** may determine the LCD configuration based on predefined criteria. For example, CPU **202** may read information from a database or a file, or CPU **202** may determine the configuration in real-time by obtaining information from related devices.

CPU **202** may also obtain user inputs (**1204**). A user of LCD system **100** may input certain information to control and/or operate LCD system **100**. For example, the user may choose a transparency mode, a color mode, and a display mode, as described below, as well as what contents to be

displayed on LCD system **100**. For example, the user may choose to display a still image, a video image, text messages, or any combination thereof via input unit **222**.

Based on the user input and/or preconfigured parameters, CPU **202** may determine a transparency mode for the LCD display (**1206**). For illustration purpose, LCD display configuration as shown in FIG. **3C** is used to describe transparency mode operation, which may also be incorporated into other configurations without departing from the principle of the disclosed embodiments.

CPU **202** may determine a full-transparent mode, in which CPU **202** may control transparency control unit **310** to be fully transparent, and may also control LCD panel **104** to be transparent as well. CPU **202** may also determine a translucent mode, in which CPU **202** may control transparency control unit **310** to reach a certain degree of transparency based on preconfigured parameters or user inputs.

Further, CPU **202** may also determine a color mode for the LCD display (**1208**). CPU **202** may set a color for LCD panel **104** to display according to the color mode. For example, CPU **202** may set a black-and-white mode for LCD panel **104**, which may include the range from a transparent LCD panel to a black LCD panel. CPU **202** may also set a particular color for LCD panel **104** to be displayed in combination of different transparency degrees to have a desired visual effect.

CPU **202** may also determine a display mode for the LCD display (**1210**). For example, CPU **202** may determine a display mode for LCD panel **104** as one of a window mode, an entertainment mode, or a bulletin mode. Other modes may also be used. When selecting the window mode, CPU **202** may control LCD panel **104** to be transparent such that a transparent window may be provided for the user. Further, the user may select certain images that are complimentary of sceneries outside the window (i.e., at the opposite side of LCD panel **104**), and CPU **202** may obtain the user's selection and control LCD panel **104** to display the certain images together with the outside sceneries. CPU **202** may also control LCD panel **104** to display certain color statically or dynamically such that a window with a various degree of transparency and colors may be provided for the user.

Further, when the user prefers to watch a video or the like, CPU **202** may select the entertainment mode for LCD panel **104**. CPU **202** may also select a bulletin mode if the user prefers to use LCD system for displaying public information or other text based information, where the transparency mode may be set to the translucent mode to have desired visual effects.

After determining the various modes for LCD display (**1206**, **1208**, **1210**), CPU **202** may control operation of the LCD display according to the configuration, the user input, and the various modes (**1212**). FIG. **13** shows an exemplary control process **1212**.

As shown in FIG. **13**, CPU **202** may obtain a natural light condition (**1302**). For example, CPU **202** may obtain the strength, brightness, or other characteristics of natural light from sensors or other devices (not shown). CPU **202** may also obtain the natural light condition based on a user input. Further, CPU **202** may determine whether natural light is sufficient to illuminate LCD panel **104** (**1304**).

If CPU **202** determines that natural light is sufficient to illuminate LCD panel **104** (**1304**; yes), CPU **202** may continue using natural light as the light source for illuminating LCD panel **104** and turn off or cancel any supplemental light sources, such as reflector, LEDs, and/or projection lamps (**1310**). On the other hand, if CPU **202** determines that natural light is not sufficient to illuminate LCD panel **104** (**1304**; no), CPU **202** may determine available supplemental light con-

figuration (**1306**). For example, CPU **202** may determine whether LCD system **100** includes any supplemental light source or sources for illuminating LCD panel **104**, such as reflector, LEDs, and/or projection lamps. Further, CPU **202** may control relevant supplemental light source or sources to supplement the natural light (**1308**). For example, CPU **202** may turn on LEDs, deploy reflectors or reflecting films, and/or turn on projection lamps. Other steps and actions may also be included.

In addition, the LCD display or LCD panel **104** may also be used as an electronic window, i.e., a display simulating sceneries from a real window. CPU **202** may perform an electronic window process **2600** as shown in FIG. **26A**. At the beginning, CPU **202** may obtain video information for the electronic window (**2602**). For example, a user may record video with respect to various scenes, such as beaches, gardens, mountains, waterfalls, and scenic spots, etc., for all-weather. The recorded video may be stored in a certain database accessible by CPU **202**, and CPU **202** may obtain video information from the database.

Further, CPU **202** may compose a plurality of window data items for display (**2604**). A window data item may refer to a basic data item to be independently displayed on LCD panel **104** for the electronic window. FIG. **26B** shows an exemplary window data item consistent with the disclosed embodiments. As shown in FIG. **26B**, window data item **2650** may include date information **2652**, time information **2654**, weather information **2656**, scene information **2658**, video information **2660**, and audio information **2662**. Other information may also be included.

Date information **2652** includes day, month, year, and season, etc., of the data item; time information **2654** includes time of the day of the data item; weather information **2656** includes what weather condition original images were taken and/or for which weather the data item is intended; scene information **2658** includes what sceneries of the original images and/or for which scene the data item is intended; video information **2660** includes the original images and other video information; and audio information **2662** includes any corresponding audio information of the data item.

Returning to FIG. **26A**, after composing the plurality of window data items for display (**2604**), CPU **202** may determine a play back mode (**2606**). For example, CPU **202** may provide various play back modes and may choose a particular display mode based on a user input or a predetermined algorithm. The various play back modes may include a basic play mode where the window data items are played in a loop according to the current date and time.

In addition to the basic play mode, the various play back modes also includes a natural play mode, in which nature light is used as backlight and background, and no supplemental backlighting is needed. The various play back modes also includes sequential play mode, in which sceneries are played in a play sequence by time and date. The various play back modes also includes a weather play mode, in which sceneries corresponding to current weather condition are played. The various play back modes also includes a season-reversing play mode, in which sceneries in a season opposite to the current season are played (e.g., summer sceneries are played in winter, etc.). The various play back modes also includes a weather-reversing play mode, in which sceneries in weather opposite to the current weather are played (e.g., snowing sceneries are played in hot days, etc.). The various play back modes also includes an emotional play mode, in which sceneries soothing people's emotions may be played. Further, the various play back modes also includes a time-difference play mode, in which a delayed scenery with respect to current

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time are played to introduce a difference in time. Other play back modes may also be used.

After determining the play back mode (2606), CPU 202 may also determine miscellaneous play back information (2608). For example, CPU 202 may determine corresponding audio to be played together with the video with proper volume and sound effects. CPU 202 may also determine auxiliary sceneries provided by auxiliary equipment, such as an oxygen generator, refrigeration equipment, a negative ion generator, an ozone generator, an ultrasonic rain and fog generator, and a smell generators, etc. CPU 202 may control the auxiliary equipment to achieve corresponding secondary effects to the sceneries. For example, when playing snow scenes, temperature is also lowered using the refrigeration equipment; when playing garden scenes, flower smell is generated using the smell generator; when playing forest scenes, oxygen is generated using the oxygen generator; when playing thunder storm scenes, negative ion generator and the ozone generator may also be used to provide negative ion and ozone, respectively, and when playing rain sceneries, rain and fog generator may be used to create rain and fog. Further, CPU 202 may control corresponding operation of the LCD display (2610).

Although the above-described display systems often involve window glass 102, the various display system may also be configured to be independent from window glass 102. For example, a such display system may include a simplified display system capable of coupling to a plurality of separate backlight devices. The simplified display system may include LCD panel 104 coupled with light guide plate 408 and controller or control circuitry 106. That is, the display system has an open-back configuration to accept backlight from various backlight sources, such as natural lights, LEDs, and other light sources. In addition, protection, support, install, and structure of these display systems may also be configured to significantly reduce cost and to improve user experience. FIG. 14A illustrates an exemplary installation of LCD panel 104 consistent with the disclosed embodiments.

As shown in FIG. 14A, LCD panel 104 may be coupled with light-guide plate 408 via coupler 1402 (e.g., coupler 302 in FIG. 3A), which may be a front-frame. That is, light guide plate 408 and LCD panel 104 may be made as a separate display component. Front frame 1402 may be connected with light guide plate 408 by using mechanical fastening means such as screws, press forming (thermo-compression), splicing, heat sealing, welding (ultrasonic soldering), molded casting, injection molding, etc. Thus, LCD panel 104 may be integrated with light guide plate 104 into a single device. FIG. 14A shows that front-frame 1402 is attached at the surface of light guide plate 408. FIG. 14B shows that front-frame 1402 encloses both edges of light guide plate 408 and LCD panel 104. FIG. 14C shows that front-frame 1402 also encloses both edges of light guide plate 408 and LCD panel 104, but does not exceed the outer surface of light guide plate 408.

As shown in FIG. 14D, light guide plate 408 may be closely coupled to LCD panel 104 to provide physical protection, support, and fixation of LCD panel 104. For example, LCD panel 104 may be glued to light guide plate 408 by glue 801, which may be a transparent or half-transparent material, or a two-sided glue film based on a transparent or half-transparent substrate.

FIGS. 15A-15C further show exemplary configurations of front-frame 1402. As shown in FIG. 15A, front-frame 1402 circumvents LCD panel 104. As shown in FIG. 15B, front-frame 1402 only covers two sides of LCD panel 104. Further, as shown in FIG. 15C, front-frame 1402 only covers one side of LCD panel 104.

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FIGS. 16A-16D illustrate exemplary configurations of light-guide 408. As shown in FIG. 16A, light guide plate 408 is connected with LCD panel 104. The size of light guide plate 408 may be larger than that of LCD panel 104, and the area beyond what is covered by LCD panel 104 is denoted as area "A". Further, as shown in FIG. 16B, one or more hollow spaces 610 may be pre-made to hold various components of the LCD display system. For example, the one or more hollow spaces 610 may hold controller 106 or other circuitry components. The hollow spaces 610 may be of any shape, and may be through or non-through.

As shown in FIG. 16C, hollow space 610 in light guide plate 408 is not through and holds controller 106. A front frame 1402 covers the area "A" as well as the hollow space 610. On the other hand, as shown in FIG. 16D, hollow space 610 is through, a back frame 402 is used to cover area "A", in addition to the front frame 1402.

Further, when coupling with light guide plate 408 and LCD panel 104, front frame 1402 may form one or more hollow spaces 620 together with light guide plate 408 and LCD panel 104, and the one or more hollow spaces 620 may be used to hold, for example, controller 106 or other control circuitry components. FIGS. 17A-17C illustrate exemplary configurations associated with front frame 1402.

As shown in FIG. 17A, front frame 1402 only covers area "A" of light guide plate 408 such that hollow space 620 is formed between front frame 1402 and light guide plate 408 over area "A". In FIG. 17B, front frame 1402 also covers an edge of light guide plate 408. In FIG. 17C, however, area "A" is no longer exists, and light guide plate 408 and LCD panel 104 are of the same size. Front frame 1402 may be used to couple light guide plate 408 and LCD panel 104 at the edge, and hollow spaces 620 may be formed at the edge of light guide plate 408 and LCD panel 104.

Further, front frame 1402 may be a single frame as shown in FIG. 17D, made of plastic, wood, or metal, and may also contain pre-made hollow spaces 620, which may also be of any shape, and may be through or non-through. FIG. 17E shows a through hollow space 620 in front frame 1402, while FIG. 17F shows an internal chamber formed inside front frame 1402 to hold controller 106 and/or other components, such as speakers.

Front frame 1402 may also be made of metal profiles (e.g., aluminum profiles) and/or non-metallic profiles. Hollow space 630 may be made during the manufacturing the metal or non-metal profiles. The front frame 1402 may thus automatically contain hollow spaces 630 when coupling or connecting light guide plate 408 and LCD panel 104. FIGS. 18A-18H illustrate exemplary configurations associated with front frame 1402.

As shown in FIG. 18A, the opening of the front frame 1402 (e.g., a metal profile) is rear-facing, and a cover 1804 may be used to cover hollow space 630 after controller 106 or other components are placed within the hollow space 630. In FIG. 18B, one or more speakers 1802 are placed within the hollow space 630. Further, in FIG. 18C, the opening of the front frame 1402 is front-facing, and is also covered by cover 1804 after controller 106 or other components are placed within the hollow space 630. Again, in FIG. 18D, one or more speakers 1802 are placed within the front-facing hollow space 630.

In FIG. 18E, the opening of the front frame 1402 is used to couple light guide plate 408 and LCD panel 104, and thus a cover is not needed. Controller 106 or other components are placed within the hollow space 630. In FIG. 18F, one or more speakers 1802 are placed within the hollow space 630. Further, in FIG. 18G, the opening of the front frame 1402 (e.g., a metal profile) may also be used to cover area "A" in addition

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to coupling or connecting light guide plate **408** and LCD panel **104**. Controller **106** or other components are placed within the hollow space **630**. Again, in FIG. **18G**, one or more speakers **1802** are placed within the hollow space **630**.

As disclosed previously, backlight system may be separated from a display system. After the separation, for large screens and/or multi-block large screens, desired mechanisms for fixing and supporting the large screens and installing the control circuitry may be needed. FIGS. **19A** and **19B** illustrate exemplary installations. As shown FIG. **19A**, a plurality of LCD panels **104** are coupled to a single light guide plate **408** during installation, while, as shown in FIG. **19B**, a single LCD panel **104** is coupled to a single light guide plate **408** and then the coupled component may be installed with other similar components to form a large screen.

For installations, controller **106** or other control circuitry may be placed only at one or two sides of LCD panel **104** to facilitate forming a large screen with other LCD panels. Further, when coupling light guide plate **408** and LCD panel **104**, the installation of the control circuit **106** can be performed by various methods as shown in FIGS. **20A** and **20B**.

In FIG. **20A**, light guide plate **408** and LCD panel **104** are coupled using an appropriate adhesive material (e.g., glue) **801**, and controller **106** or other control circuitry is fixed at a side of LCD panel **104** using glue or resin **802**. In FIG. **20B**, controller **106** or other control circuitry is fixed at an edge of light guide plate **408** also using the adhesive material **801**. Further, a thin film of plastic or metal protection cover **2002** is used to wrap the edge of the coupled devices to protect controller **106** and other devices.

Further, in a large screen or ultra-large screen system, a display system and a backlight system can be connected together by a rotating structure. The rotating structure can be arranged on either side of four sides of the display system or the backlight system. As shown in FIG. **21A**, rotating structure **2106** is arranged at the upper side of backlight system **2102**, display system **2104** may be opened around rotating structure **2106** in an up-down manner. While, in FIG. **21B**, rotating structure **2106** is arranged at the right side of backlight system **2102**, display system **2104** may be opened around rotating structure **2106** in a side-by-side manner. Further, the backlight system **2102** may be generally installed on the wall, windows, or doors, with specific supports or bases.

Thus, more generally, a display system and a backlight system may be separately made and may be coupled together during installation or integration to form an entire system. The display system may refer to previously disclosed and/or explained various components coupled together, without the backlight system, to form a display function, such as LCD panel **104**, light guide plate **408**, controller **106**, and front frame **1402**, etc. The display system may support various backlight systems. Various configurations for arranging the display system and backlight system may be supported.

For example, in FIG. **24A**, window glass **2402** is coupled to display system **2404**, and the natural light is the only backlight source for display system **2404**. In FIG. **24B**, an LED belt(s) **2206** is attached to window glass **2402** such that both the natural light and the LED belt **2206** are backlight sources for display system **2404**, i.e., when natural light is sufficient to backlight display system **2404**, LEDs in LED belt **2206** are turned off, and when natural light is not sufficient or does not exist, LEDs in LED belt **2206** are turned on to provide backlight to display system **2404**. That is, the LED is used as a supplemental backlight to the natural light.

Further, in FIG. **24C**, LED belts **2206** are attached on flexible light reflecting sheet material **2304** controlled by wheeling device **2302**, which is coupled between window

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glass **2402** and display system **2404**. As previously explained, when natural light is sufficient for providing backlighting, wheeling device **2302** may be controlled to retract sheet material **2304** such that the natural light alone is used for backlighting. However, when natural light is not sufficient for providing backlighting, wheeling device **2302** may be controlled to deploy sheet material **2304** such that the LED belts **2206** are used for supplementing or replacing the natural light.

In FIG. **24D**, LED belts **2206** are arranged on light reflecting plate **2306** controlled by automatic mechanism **2308**, which is coupled between window glass **2402** and display system **2404**. Also as previously explained, when natural light is sufficient for providing backlighting, automatic mechanism **2308** may be controlled to move plate **2306** to uncover display system **2404** such that the natural light is used for backlighting. However, when natural light is not sufficient for providing backlighting, automatic mechanism **2308** may be controlled to move plate **2306** to cover display system **2404** such that the LED belts **2206** are used for backlighting.

Further, optical fibers may be used to guide natural light or other light as backlight sources. In FIG. **24E**, optic fiber device **2414** may be used to guide natural light into light-guide **2412** as the backlight for display system **2404**, reflector or reflecting film **2416** is used to improve efficiency.

In addition, LEDs may also be used together with optic fibers to supplement the backlight. In FIG. **24F**, LED belts **2206** is arranged on light-guide **2412** to supplement the natural light guided into light-guide **2412** by optic fiber device **2414**. when natural light is sufficient for providing backlighting, LEDs in LED belts **2206** are turned off such that the natural light is used for backlighting. However, when natural light is not sufficient for providing backlighting, LEDs in LED belts **2206** are turned on such that the LED belts **2206** are used for supplementing or replacing the natural light. Further, in FIG. **24G**, LEDs **2418** are directly placed on the edge of light-guide **2412** such that optic fiber device **2414** and LEDs **2418** can also both provide light sources into light-guide **2412** as backlight to display system **2404**.

Further, other types of light may also be used as backlight sources. For example, in FIG. **24H**, a plurality of cold cathode fluorescent lamps (CCFLs) are provided as the only backlight source for display system **2404**, and reflector or reflecting film **2416** is used to improve efficiency. For another example, in FIG. **24I**, LED belts **2206** may be used for the only backlight source for display system **2404**, and reflector or reflecting film **2416** is also used to improve efficiency.

Moreover, the various light sources may also be used to provide backlight for back-to-back display systems. A back-to-back display system may include two display systems configured in a back-to-back manner to display information on both display systems. For example, in FIG. **24J**, two LED belts **2206** are glued on the two sides of a reflecting plate **2420**, respectively, such that the two LED belts **2206** independently provide backlighting to two back-to-back display systems **2404**. In FIG. **24K**, a plurality of CCFLs **2420** are coupled between two back-to-back display systems **2404** to provide backlighting. Further, in FIG. **24L**, optic fiber device **2414** and light guide plate **2412** are used to provide backlighting to the two back-to-back display systems **2404**. LEDs **2418** are provided to supplement or replace the natural light or other light source from optic fiber device **2414**. Further, reflecting film **2424** may also be placed within light guide plate **2412** to improve lighting efficiency.

Light guide plate **2412** may include any appropriate type light guide materials. For example, as shown in FIG. **25B**, light guide plate **2412** may include a thin film **2430** by casting

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the pre-made thin film **2430** into light guide plate **2412** during the manufacturing process. Further, as shown in FIG. **25A**, thin film **2430** may be made with a plurality of reflecting convexes **2432** using, for example, printing methods. Thus, in FIG. **25B**, incorporating the thin film printed with the plurality of reflecting convexes **2432**, a plurality of reflective pits may be formed within light guide plate **2412** for guiding lights entering from the side of light guide plate **2412**. Further, the density and size of the reflective pits may be adjusted when printing the thin film **2430** (e.g., a reflective film). Further, in FIG. **25C**, film **2430** may be made with a plurality of reflecting convexes **2432** on both sides to form a two-side thin film **2430**. FIG. **25D** shows a two-side light guide plate **2412** incorporating the two-side thin film **2430** having printed plurality of reflecting convexes **2432** on both sides of thin film **2430**. Other configurations may also be used.

FIGS. **27A-27D** illustrate exemplary signaling systems based on disclosed display systems. As shown in FIG. **27A**, signaling system **2700** may include an LCD display panel **2702**, a series of convex lenses **2704**, optic fibers **2706**, and a signaling panel **2708**. Other components may also be included.

LCD display panel **2702** is positioned on top of a plurality of convex lenses **2704** and exposed to sunlight. LCD display panel **2702** may be controlled to allow or not allow sunlight coming through LCD display panel **2702**, and how much sunlight is allowed coming through, by control the transparency of the LCD display panel **2702**. Sunlight passing through LCD display panel **2702** may be converged by convex lenses **2704**. A plurality of optical fibers **2706** are positioned on the focal plane of convex lenses **2704**. A plurality of optical fibers may be grouped together at the signal panel **2708**. Concentrated and brightness-enhanced sunlight coming out of signal panel **2708** to create certain visual signals.

In FIG. **27B**, instead of a single display panel **2702** in FIG. **27A**, a plurality of LCD display panels **2712** are used, each corresponding to a convex lens **2704**. Further, FIGS. **27C** and **27D** correspond to FIGS. **27A** and **27B**, respectively. However the positions of LCD display panel **2702** (and display panels **2712**) and convex lenses **2704** are switched. Because optic fibers **2706** is flexible, LCD display panel(s) may be adjusted to face a direction with strong sunlight, and the signaling panel **2708** may also be adjusted to face a proper direction.

FIG. **28A** shows an exemplary signaling panel **2800**. As shown in FIG. **28A**, signaling panel **2800** includes a plurality of optic fibers **2706** and, optionally, a plurality of LEDs **2804**. The LEDs **2804** may supplement the sunlight when needed.

FIG. **28B** shows an exemplary signaling panel **2850**. As shown in FIG. **28B**, signaling panel **2850** includes a plurality of panel elements **2806**, and each circular element **2806** has an area 'B'. During operation, signaling panel **2850** can be turned on and off by allowing or disallowing sunlight passing through LCD display panel **2702** or LCD display panels **2712**, and the brightness of signaling panel **2850** can be controlled by adjusting the size of area 'B' of panel elements **2806**. Signaling panel **2850** may also be black-and-white or color by processing the sunlight. Further, in FIG. **28C**, a panel element **2806** may be in a shape of circular strip, while in FIG. **28D**, a panel element **2806** may be in a shape of a circular slice.

The disclosed LCD display systems may also be made into self-contained integrated display systems, with or without natural light backlighting. These display systems can be used for computer monitors, televisions, portable computers, digital picture frames, electronic books, cell phones, and two-sided display, etc. FIG. **29A** shows an exemplary structure for

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such systems. As shown in FIG. **29A**, display structure **2900** includes light guide plate **408** and LCD panel **104**, similar to structures described in FIGS. **16A-16D**. Light guide plate **408** is used as a main support structure for structure **2900**, not only supporting LCD panel **104** and other components, but also providing a plurality of hollow spaces **610** for hosting control circuit or controller **106**, a light source **410** and other components.

In FIG. **29B**, hollow spaces **610** are further covered by a front frame **1402**, and the light guide plate **408** is further covered by a cover **2904** on the side not coupled to LCD panel **104**. In FIG. **29C**, hollow spaces **610** are through. In FIG. **29D**, hollow spaces **610** are not through, however light guide plate **408** and front frame **1402** fit at the edge. Further, FIG. **29E** is similar to FIG. **29D**, however hollow spaces **610** are through in FIG. **29E**. In FIG. **29F**, front frame **1402** covers all sides of structure **2900** except the side with LCD panel **104**, and hollow spaces **610** may be formed by front frame **1402**.

As explained previously, hollow spaces **610** may contain controller **106** and other control circuitry, backlighting light source **410**, and other components. As shown in FIG. **30A**, hollow spaces **610** from upper side and lower side of light guide plate **408** host light sources **410**, which emit light towards the center of light guide plate **408**, such that the light can be guided toward to LCD panel **104**. Also, controller **106** and other control circuitry are hosted in a left side hollow space **610** and a lower side hollow space **610**. In FIG. **30B**, controller **106** and other control circuitry are hosted in an upper side hollow space **610** and a lower side hollow space **610**, same as the light sources **410**.

In FIG. **30C**, controller **106** and other control circuitry are hosted in an upper side hollow space **610** and a lower side hollow space **610**, same as the light sources **410**. Front frame **1402** covers the hollow spaces **610**, and cover **2904** covers the entire other side of light guide plate **408**. In FIG. **30D**, a two-sided display is used, two LCD panels **104** are coupled together with light guide plate **408**, and two front frames **1402** are provided to cover hollow spaces **610** on both side of the display. Further, in FIG. **30E**, front frames **1402** and light guide plate **408** fit at the edge, and in FIG. **30F**, front frame **1402** wraps around the edges.

The integrated display systems may be used in various applications. For example, FIGS. **31A-31B** show an exemplary portable computer or electronic book. As shown in FIG. **31A**, portable computer **3100** may include light guide plate **408**, LCD panel **104**, control circuitry **106**, light source **410**, rear frame **402**, and front film **3102**. Front film **3102** may include any appropriate film for touch screen applications. In FIG. **31B**, rear frame **402** is replaced by another front film **3102**.

In FIG. **32**, a two-side display system for computer room applications is illustrated. In FIG. **33**, an attachable display system is illustrated. A thin film **3202** (e.g., reflective film, adhesive film) is used to cover the non-display side such that the display system can be attached to other structures.

Other embodiments of the disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the disclosure herein. It is intended that the specification and examples be considered as exemplary only, with the scope being indicated by the following claims.

What is claimed is:

1. A liquid crystal display (LCD) system, comprising:
  - a first light source;
  - a self-contained display unit including at least a LCD panel and a light guide plate coupled together, wherein the light guide plate is configured to guide light from the first

- light source to the LCD panel as backlight and to structurally support the LCD panel;
- a plurality of pre-made hollow spaces contained in the display unit configured to host components of the LCD system;
- a controller contained in the plurality of pre-made hollow spaces and coupled to the LCD panel to control the LCD panel such that the light passing through the light guide plate is used as backlight for operation of the LCD panel; and
- a self-contained backlight unit providing a second light source and coupled to the display unit, wherein the self-contained backlight unit provides the second light source to supplement the first light source and includes a plurality of light emitting diode (LED) belts configured to be retracted by a wheeling device when the first light source is sufficient for backlighting and to be deployed when the first light source is not sufficient for backlighting.
- 2. The LCD system according to claim 1, wherein: the plurality of pre-made hollow spaces are made in the light guide plate in an area uncovered by the LCD panel.
- 3. The LCD system according to claim 1, wherein: the self-contained display unit further includes a front frame coupled to the light guide plate using at least one of mechanical fastening means, compression forming means, splicing means, heat sealing means, ultrasonic welding means, molded casting means, and injection molding means.
- 4. The LCD system according to claim 3, wherein: the plurality of pre-made hollow spaces are made in the light guide plate in an area uncovered by the LCD panel and covered by the front frame.
- 5. The LCD system according to claim 3, wherein: the front frame is made of metal profiles.
- 6. The LCD system according to claim 1, wherein: the first light source is natural light and the second light source is LED light.
- 7. The LCD system according to claim 1, wherein: the light guide plate is coupled to a plurality of optic fibers to receive natural light from the first light source.
- 8. The LCD system according to claim 7, wherein: the light guide plate is coupled to a plurality of LEDs in addition to the plurality of optic fibers to supplement the backlighting.
- 9. The LCD system according to claim 1, wherein: a display unit includes a second LCD panel coupled to the light guide plate to form a two-side display.
- 10. The LCD system according to claim 1, wherein: the light guide plate includes a film printed with a plurality of reflective convexes within the light guide plate such that a plurality of reflective pits are formed within the light guide plate.
- 11. A liquid crystal display (LCD) system based signaling system, comprising:
  - one or more LCD panels configured to receive natural light;

- a plurality of convex lenses coupled to the LCD panels to concentrate the received natural light;
- a plurality of optic fibers configured to receive the concentrated natural light at one end and to couple with a signaling panel at the other end such that the received light from the optic fiber is used to provide various signals on the signaling panel, wherein the signaling panel is turned on and off by controlling the LCD panels to allow or not allow the natural light passing through the LCD panels.
- 12. The LCD system based signaling system according to claim 11, wherein:
  - the optic fibers are configured into a plurality of panel elements, and a brightness of the signaling panel is controlled by adjusting a size of areas of the panel elements.
- 13. The LCD system based signaling system according to claim 12, wherein:
  - the panel elements are in one of a circular shape, a circular strip shape, and a circular slice shape.
- 14. The LCD system based signaling system according to claim 12, wherein:
  - the panel elements include a plurality of light emitting diodes (LEDs) to supplement the natural light.
- 15. A liquid crystal display (LCD) system, comprising:
  - a display system without backlighting and capable of being coupled to a plurality of backlight sources; and a separate backlight system coupled to the display system to provide at least one of the plurality of backlight sources, wherein the display system includes at least a LCD panel, a light guide plate coupled to the LCD panel, and a control circuitry; the light guide plate is configured to guide light from the at least one of the plurality of backlight sources to the LCD panel as backlight and to structurally support the LCD panel; and the LCD panel is coupled to the light guide plate by a glue layer, wherein: the glue layer is made of glue or a two-side glue film based on a substrate and is transparent or half-transparent, the light guide plate is coupled to a plurality of LCD panels such that the LCD system supports a substantial large screen, and the control circuitry is installed on one or more sides of the light guide plate without covering the LCD panels.
- 16. The LCD system according to claim 15, wherein: the control circuitry is fixed at the edge of the light guide plate using glue or resin.
- 17. The LCD system according to claim 15, wherein: the control circuitry is glued to the edge of the light guide plate using the two-sided glue film, and covered by a thin film of plastic or metal.
- 18. The LCD system according to claim 15, wherein: the display system and the backlight system are coupled via a rotating structure such that the backlight system is installed on a fixed base and the display system is selectively opened along the rotating structure.

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